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Safety in Electrical Installations.

Although it has ceased to be the fashion to ascribe all fires of unknown origin to electric wires it is undeniable that the use of electric current for light and power does not eliminate danger to life and property. Electric light and power is certainly as safe as any other, on the whole safer, but its recent introduction on, so to speak, a sensational scale has drawn to its dangers rather more than their fair share of attention. From the practical standpoint of the man who uses, the risks incurred in taking on electrical equipment are chiefly those to property, the risks of fatal accidents lying mainly outside the premises of the user. Yet these risks to life cannot be put aside since now and then accidents happen in very unexpected cases and from very singular combinations of circumstances. One of the most natural and commonest questions asked of engineers is: How much electricity does it take to kill a man? Now since, save for electrocutions by law, which are designed not to experiment but to kill in the most effective and expeditious manner, all the evidence on the question is accidental, one must appeal to experience for the answer.

So far as can be ascertained death from electric shock is mainly a question of the amount of current forced through the body, and this in turn is dependent on the voltage and the resistance in circuit, including the body, of which the resistance is mainly at the contacts. Hence with poor contacts one may sometimes survive the application of high voltage, or on the other hand may die if the contacts are good on a comparatively low voltage. There are at least two well-authenticated cases of fatal shock from 220-240 volts of direct current. In both the possibility of a cross of the conductors with higher voltage was eliminated and the victims were in good health, but the contacts were phenomenally good. There have been many deaths from street railway circuits of 500 to 600 volts under conditions of good contact, but generally speaking, shocks from such circuits are merely unpleasant, the voltage not being enough to furnish much current through the normally high resistance of the body. Alternating current is intrinsically more dangerous owing to the added effect of nervous shock, but again the results depend on contact conditions. There have been a good many deaths on alternating-current circuits of 200 to 400 volts, but also a vast majority of merely unpleasant shocks and burns. At 1,000 volts alternating current and upward fatal results are common, but such circuits are rarely installed in buildings. Ordinary arc lighting circuits, either direct current or alternating current, have probably caused more deaths than all other circuits put together, a result due largely to the immense mileage of wire and the practical certainty of the circuits being grounded through trees.

As to measures of safety, theoretically one may touch at any one point a wire otherwise insulated from earth without material risk. Practically all high voltage circuits must be regarded as dangerous through being somewhere grounded, and all wires should be regarded as alive until proved to be dead. One of the commonest sources of danger in work out of doors is the crossing of innocent wires, like telephone and telegraph wires, guy wires and so forth, with high-voltage circuits perhaps at a point far out of sight. It is wise, therefore, to treat all wires, even insulated ones, of which both ends cannot be seen, as potentially risky, and to treat them with becoming respect. If they are in the way, let their owners assume the responsibility of taking proper precautions in clearing them. Fortunately, high voltage circuits are rarely installed indoors, and one who is concerned merely with using electric lights and motors runs little risk. There is a slight chance that the primary high-voltage current on alternating-current systems may break through into the service circuits. This risk can be averted by grounding the secondary circuit, which should always be done. As regards any danger from the service circuits, which rarely exceed 250 volts, the best plan is to see that they are insulated at all points and that one cannot be in contact with them while also in contact with the ground or a grounded conductor like a gas or water pipe or an iron beam reaching ground. In other words keep the conductors well insulated, and even so as far as possible out of reach.

As regards danger from fire there is no material distinction between alternating current and direct current, or between circuits covering the ordinary range of voltages. Common 110-volt lighting circuits have caused as many fires as any others, even making allowance for their number. The rules of the fire underwriters embodied in the National Code, if conscientiously lived up to, render the fire risk pretty nearly negligible. They were constructed with this in view. No rules, however, can prevent violations or ensure safe work if one is trying to dodge their application. For an honest and competent man the National Code is in some respects needlessly severe; for a knave or a fool it is insufficient. The chief danger in installations comes from scamping or from careless temporary work. The latter has been responsible for all sorts of trouble. A discreet wireman can do a thoroughly safe job of temporary construction which would violate the letter of the Code in many places, while a careless one might run into danger at once. The best policy is to avoid temporary work so far as may be, and to live up to the spirit of the Code. If temporary work has to be done, let it be done only by a skilled man with full liberty to use the very best materials. It is a good plan in all temporary work to run all circuits where they are plainly visible and can be inspected. Concrete work of any kind should be done deliberately and only with the best of material. If the Code be honestly followed, trouble is remote. The best general injunction, in addition, is to keep everything around the electrical equipment clean and dry. If part of an installation has to be in a damp place take the extra precautions that the Code directs, and do not let the conditions change without taking pains that the equipment is kept up to the new conditions. Temporary work, dirt and moisture are the chief enemies of safe operation. If one avoids these, he may lay his worries aside.

Power Plant Extensions.

The engineering problems connected with the extension of a modern power plant are scarcely less important than the questions to be settled in the design of the original installation. The cost of expansion is largely determined by the consideration given to the probable growth of the plant before its service operation begins, and failure to allow for future loads by providing room for symmetrical development is as unwise as to tie up the entire production of an industrial establishment by the installation of but one generating unit without the reserve of central station breakdown service.

Increase in power plant capacity must be viewed from one of two standpoints. Expansion along predetermined lines is one aspect of the general problem, and enlargement without immediate reference to the original design, the other. It is often impossible to allow the space necessary for more than a small percentage increase in capacity, as in the case of an office building occupying land of high value. Fortunately in this class of work the ultimate capacity required is not difficult to determine, and the completion of the building or group of buildings served from a central plant sets the limit to the number of machines, and therefore the plant space required. Commercial central stations almost invariably allow for expansion of their original plant; railway power plants frequently do so also; but it is often the case in industrial power plants that the problems of future growth are overlooked in the haste to begin manufacturing and in the incidental consideration given to the power question in comparison with labor and material issues. It is this latter class of plants which is prone to suffer in economy and become inadequate in capacity as the business in general expands.

When it is feasible for a plant to be extended by the addition of units similar to its previous equipment and located in places assigned on the original plans, the problem is largely one of routine. The principal issue in such cases is the prosecution of the new construction without serious interference with the regular service. Complete separation of old and new machinery by partitions of wood or canvas facilitates matters greatly. Supervision of the contractors' methods at such times is specially desirable, and the institution of economies in handling materials and machinery, the avoidance of obstruction in the operating sections of the plant, and the utilization of existing power facilities are well worth studying. With a good organization it is often feasible to carry out an extension requiring the services of several hundred men without the least interference with the routine work of a plant, and in fact, with practically no evidence in the operating rooms that expansion is taking place, beyond the existence of a special curtain wall at one end of the structure. The extensions now under way at the Lincoln power station of the Boston Elevated Railway Co. furnish a good illustration of how a plant may be increased 66.6 per cent. in capacity without visible interference with its routine service. This expansion is taking place separately along predetermined lines; two 2,700-kw. units are being added to three outfits of like capacity and generally similar designs, though of different make; and as the space required was laid out some seven years ago with a view toward future expansion, the company is now reaping the benefit of its policy of retaining enough real estate in this location to avoid the costly process of enlarging its capacity by tearing out old equipment to make room for new and higher-powered units.

Even if the requisite space for expansion be laid out in the original design of a plant, the selection of generating unit sizes and types in increasing the capacity is a most important problem. It is the province of the consulting engineer to determine these issues, but the character of installations sometimes encountered in various parts of the country indicates that expert advice may have been sought in the design of the original plant, but that the extensions were made with the purchasing agent as the chief technical consultant. The natural course for the layman to follow in extending his plant is to order another machine which duplicates a previous unit, assuming that the latter has made a decent record in service. The benefits of larger powered units, possibly of improved type and perhaps of different make, are liable to be entirely missed if a plant owner buys increased capacity without an expert analysis of his operating and maintenance records with reference to the enlarged demands brought about by new conditions of service. In many cases it works out that the purchase of a third or fourth unit duplicating one of the original machines is the proper course to follow, but in other instances a totally different style of machine is the correct solution of the problem. The practice of building complete foundations with bolt holes for extra units to be installed a couple of years or more after a plant is first completed becomes objectionable if the later conditions require machines of a design radically different from the originals, as it frequently leads to extra cost through the tearing down and rebuilding of foundations unsuited to the altered conditions.

It is often argued that the installation of turbines in a reciprocating engine plant complicates the operating conditions too much in the direction of varied demands upon the men and increased number of spare parts required, coupled with radical differences in maintenance methods, but these objections are of little weight with a good organization. Few engineers are as yet ready to extend a steam plant by adding gas engines and producers to the existing boiler and reciprocating or turbine engine installation, though the interests of cheap power production and the development of large gas-driven prime movers are constantly leading us nearer the serious consideration of what at present seems an incongruity.

If these points emphasize the need of expert advice, either from the regular organization of the operating company or from an outside engineer, in the extension of plants where the original plans provided for added units of definite capacity, trained judgment is manifestly much more essential in the enlargement of a plant where lack of space demands the removal of one or more old units of moderate capacity to make room for new and relatively more compact machines of larger rating. The value of overload capacity in specific cases as compared with additional units, the relation between all day economy and machinery sizes, the decreasing need of small machines as the general load increases, the probable ultimate capacity demanded in a given plant area, the estimated cost of rebuilding in part, the selling price of second-hand machinery, and influence of deliveries delayed beyond contract schedules, these questions cannot be solved offhand with any certainty that the cost of operation in the long run, including the quality of the service as it affects the production rate of the establishment, will be at the minimum which should be obtained with skilled engineering advice.

The American Society for Testing Materials.

The tenth annual meeting of the American Society for Testing Materials was such a large and important gathering that the reason for the growth of the association in size and influence could be well understood by anybody attending the sessions for the first time. There are many technical societies and trade organizations, but the American Society for Testing Materials seems to be the only one in which manufacturers and consumers of engineering materials meet on a common footing for heart-to-heart talks concerning the quality of such materials and the methods of determining it. The time has gone by when an engineer can say that he wishes material of certain properties and can also specify of his own knowledge how those qualities shall be produced by manufacturing processes. The large producers of engineering materials now have technical staffs of marked ability. The information of a scientific nature which these specialists obtain is of the highest value and any neglect to take full account of such information in preparing specifications is bound to result in trouble to the consumer. Accordingly this association conducts a large part of its work by committees made up equally of consumers of materials and the manufacturers of them. In this way both parties are evenly represented in the committee work, and there is no opportunity for the engineer to force the adoption of impracticable requirements nor for the manufacturer to neglect to take full account of the changed requirements which progress in engineering makes necessary. Accordingly the specifications which these committees present to the society for its adoption are generally in advance of those of any single interest, and represent as close an agreement with the best work in any particular industry as a standard specification can. Of course for special cases special specification must be needed. This is an inevitable consequence of the requirements of some kinds of work, and if purchasers of engineering materials need such special products, they must naturally expect to pay more for them than those made under standard specifications, which permit manufacturing in bulk. Probably none of the standard specifications of this society represents completely the views of any one member of the committee which prepared them, but on the contrary it is an expression of the composite judgment of men who have been long interested as consumers or producers, of the requirements which will be satisfactory for enough users to be considered standard.

In order to prepare such specifications it is essential to have a thorough knowledge of the strength of materials and of the methods of testing to determine such properties, and accordingly an important feature of the society's work is investigation along this line. The meetings of the society are always marked by important papers concerning new properties of materials and methods of research which have been developed in the laboratories of both consumers and purchasers. For instance, at the meeting of last week, Mr. Henry Souther, director of the laboratory of the Association of Licensed Automobile Manufacturers at Hartford, where a large amount of valuable work is now being done, presented a paper giving information concerning endurance tests, which are rapidly coming to the forefront as a means of ascertaining properties of special steels which must be determined in order that high-grade machinery, such as the automobile requires, may be constructed both strong and light. Another paper was that by Dr. A. S. Cushman, assistant director of the office of public roads of the Department of Agriculture, which described research work to develop a really satisfactory theory of the corrosion of iron. This is the first public presentation of his electro-chemical theory, although information concerning it has been communicated to a committee of the society engaged in studies of methods of protecting iron and steel. The importance of this paper is evident from the fact that Dr. Chas. B. Dudley referred to it as the statement of research work which he considers the most influential contribution to our knowledge of the subject during the last twenty-five years.

It is only natural that in a society devoted to subjects of this nature and containing representatives of both manufacturers and consumers, that a considerable conflict of opinion should sometimes arise. For example, at the present time steel rails are attracting a great deal of attention from the public as well as from railroad officials and the managers of mills. It is one of the most troublesome problems of a technical nature in the steel industry. The American Society for Testing Materials took it up a good many years ago and its committee has been working steadily ever since to draw up a standard specification under which railroads would be sure to obtain reasonably satisfactory materials while manufacturers would not be subjected to unnecessary hardships. The committee finally reported its specifications at the convention of last week. They contain requirements which the rail mills would have denounced as unjust a few years ago and make concessions that many engineers would have considered unwarrantable had it not been for the discussions of the subject which have taken place not only in committee meetings but also in the conventions of the society during recent years. The discussion of these specifications last week, which led to their being ordered to a letter ballot of the society, was a very interesting one. The fairness of it was in marked contrast with statements which have been published in the daily papers and even in some technical journals. The railroad representatives who took part acknowledged that the great increase in train loads was responsible for some of the rail troubles that have been occurring of late. They further acknowledged that the standard American Society of Civil Engineers section was not a good one in its heavier sizes. On the other hand they all agreed that better rails were necessary, and if they would cost more to produce it was their opinion that the companies with which they were connected would have no objection to paying a reasonably increased price. But in order to secure this better quality, while conceding everything that manufacturers wished in the way of a better section, they felt warranted in requiring certain improvements in the processes of manufacture, notably a sufficient time in each one of the steps of manufacture to insure that the metal which was finally rolled in the rails was free from imperfection. The representatives of the rail mills, while pointing out that it was desirable, for the sake of high quality, to keep the mills running continuously, asked for all suggestions to be given to them concerning any occasion of failure to take due time at every stage in the manufacturing process, for it was their intention to turn out only a high-grade and safe product. Anybody who listened to the discussion of these specifications and was acquainted with the long work necessary to produce them, could not seriously question the importance of the society as a clearing house for information regarding engineering materials. Probably such a standard specification could not be prepared in any other manner than that followed in the work of the committee which drew it up. That it will remain unchanged for many years seems hardly likely, but it is an excellent expression of opinion of what a standard rail should be at the present time. Some great corporations, like the Pennsylvania Railroad Co., may find it advisable to adopt different requirements, but the specifications as a whole will enable most roads to secure better rails than they are now getting provided the requirements are rigidly lived up to, something that must be intrusted to the inspectors in any case. It is true, of course, that in the case of steel rails the ultimate decision concerning what shall be considered standard rests with the heads of the railroads and the manufacturing companies, rather than with their technical advisers, and as these executive officials are expected to take up the subject shortly, possibly the specifications which have just been adopted will need modification very soon. It is safe to say, however, that they will form a most useful basis for any discussion in the future and on that ground alone fully justify all the labor that has been spent on them.

Appraisals of Engineering Equipment.

The determination of the value of equipment which has seen service is a task which frequently falls to the engineer, regardless of whether he be a specialist along mechanical, civil, electrical or other lines. Just as in preparing estimates the reports of different engineers seldom follow a standard form, a wide latitude for individual judgment exists in connection with appraisals. To a considerable extent, of course, all appraisals are estimates, but in a larger sense they refer to present and past values, while estimates deal more generally with future conditions.

From some points of view an appraisal is merely a matter of spending an hour or so in a plant or industrial establishment and sizing up in a rough way the total present value of the physical equipment. It is often thought undesirable to spend any length of time in settling the value of old equipment from the standpoint of the second-hand sale of it, for there is always a pretty heavy shrinkage below the original cost in such cases. Conditions of course largely determine how much effort should be expended on appraisals, but in general the careful appraisal tends to secure a better price and a sounder decision regarding changes in the equipment than one made in a hasty and ill-considered fashion by some inexperienced assistant of the consulting engineer or expert auditor who is employed for the work.

Certain main points ought not to be overlooked in the making of equipment appraisals in any careful way. The first cost of the equipment should be known in detail as far as possible; for while the value of the plant in even a few years is bound to be far below the original investment, as far as redeeming it by a sale is concerned, the existence of accurate data of first cost sets a maximum limit from which one can safely work downward, basing each approximation upon the other conditions to be taken into account. Only a wise treatment of the depreciation problem should be one of the main objects sought in handling an appraisal on a broad scale, and the larger the aggregate of equipment, the more essential it becomes that individual pieces of machinery shall be treated separately in the analysis of values before adding up the totals of each class. Off-hand valuations are undesirable features of otherwise careful reports. It is not the purpose of these comments to set values for depreciation in different kinds of plants; that is a problem which cannot properly be compressed into the limits of a few paragraphs, though in some reports which have been presented there is a surprising freedom in the use of sweeping percentages to cover groupings of equipment and heterogeneous conditions. At the same time an appraisal which fails to consider depreciation as fully as circumstances permit runs grave risk of becoming little more than typewritten guesswork.

A point often overlooked in the preparation of appraisals is the approximate cost of replacing worn equipment by apparatus of the latest design. Obviously no set of machines which can be replaced by new and more efficient outfits at a lower factory cost than that of the first installation is likely to remain long in its original service if the operating company is alive to its opportunities unless it can be shown clearly that the cost of making the change is too high in proportion to the value of the equipment. These points render an occasional appraisal, say at least once a year, a suggestive piece of work, and they justify not a little care to secure at least approximate prices of the most modern equivalent equipment. It is not uncommon experience to install a new plant equipped at a certain cost with improved apparatus and to find in a few years that the same machines or perhaps improved designs of the first outfit can then be put in at less expense because of the increased demand for their manufacture on a large scale without much subsequent development expense. A sound appraisal must take account of these conditions, if they exist, in order to escape the absurdity of valuing old equipment above new apparatus capable of superseding it. The prospect of early development which shall further reduce the economic efficiency of a plant may be considered incidentally in the appraisement of industrial property, but ordinarily progress not actually available at market prices can be safely neglected in valuing equipment from the owner's standopint. It is not enough to call in a second-hand machinery man and unquestionably accept his estimate; what is needed is a thorough physical examination of the property with reference to its service, capacity and reliability condition as compared with new apparatus, and its record in the years of its operation. Some of these factors are elusive; others are definite in a well-run establishment, and in their discriminating combination lies the opportunity of the experienced engineer to hand in a financial total for a given installation which represents the best results consistent with the limitation of each personal equation and set of conditions that are brought together.

Notes and Comments.

ADVOCATES OF THE METRIC SYSTEM will be gratified to notice that the Baldwin Locomotive Works have recently built twenty 10-wheel locomotives for the Orleans Ry. of France. These are compound locomotives of the De Glehn system, and were built to drawings furnished by the railroad company, all measurements on the drawings being in the metric system.

STREET PAVEMENTS between and for 2 ft. on either side of the outside rails of street railway tracks are laid and maintained at the expense of the railway companies in the State of New York, in accordance with Section 98, Chapter 39, of the general laws enacted in 1890. Much difficulty is experienced in compelling the companies to conform to this act, and the authorities of Rochester were recently compelled to take such a case of refusal to the United States Supreme Court. The Rochester Railroad Co. was incorporated under the laws of 1884, containing a similar provision to that mentioned, to take over the property of the Rochester City & Brighton R. R. The latter was incorporated under the general laws of 1850, and in 1869 was relieved by a special act from keeping any part of a permanently improved street in repair. Since 1898 the new company has refused to pay any part of the cost of repairing along the lines of the old company, on the ground that it is the successor to all the privileges of the old company, among them exemption from such charges. The Supreme Court has ruled, however, 27 Sup. Rep., 469, that a new company incorporated under the laws of 1884, cannot claim the benefit of any contract exemption from a contract exemption enjoyed by a predecessor in title.

AN ELECTROLYSIS PROBLEM which seems likely to attract attention has arisen in recent years in New Bedford. The city receives its supply through a 48-in. steel force main, which has been damaged by the return currents of the Old Colony Street Ry. for several years, and evidences of marked deterioration have been frequently detected. The attention of the railway company has been called to this continued destruction by the Board of Water Commissioners, and after long delay the company bonded its tracks in the vicinity of the main and put an insulating joint in a service pipe running from it which was carrying a large amount of current. Mr. Wm. E. Foss, who has investigated many electrolytic conditions in Boston and vicinity, was engaged to report on the protective measures taken in New Bedford, and as a result of his investigations he states that the bonding of the track and the use of an insulated joint were of no service. In his opinion the only remedy will be the introduction of a double trolley on this road, which he does not regard as a serious burden in view of the nature of the traffic. Inasmuch as the city depends for its water supply on this force main, and its destruction by electrolysis seems very likely, the National Board of Fire Underwriters has taken up the matter and urged energetic and drastic action against the railroad company to compel it to keep its return currents off the main. Inasmuch as fire underwriters generally succeed in the course of time in accomplishing their purpose, it seems likely that the Old Colony Street R. R. Co. will shortly find itself facing a pretty serious situation. Any failure of the New Bedford water supply due to electrolysis would arouse public condemnation in a manner likely to be remembered.

THE TAYLOR'S FALLS, MINN., WATER-POWER DEVELOPMENT.—I

An important water power development has been made on the St. Croix River, which forms the boundry between the States of Minnesota and Wisconsin, by the Stone & Webster interests, of Boston. This development supplies the Minneapolis General Electric Co. with additional current for lighting and power business in Minneapolis and for general distribution as wholesale power through the manufacturing districts in and around Minneapolis and St. Paul. The development was put in operation in December, last, and is operated by the Minneapolis General Electric Co. in connection with its local plants. The system consists of a dam and power house at Taylors Falls, Minn., on the St. Croix River, about forty miles from Minneapolis; a transmission line from this plant to a step-down substation at the city limits of Minneapolis and St. Paul and a system of tie lines connecting with the power plants and sub-stations of the Minneapolis General Electric Co., in Minneapolis. In connection with this development an existing lumbermen's dam about eleven miles above the St. Croix dam has been secured for storing and controlling the flow of the river.

The water-shed of the St. Croix River covers an area of about 6,000 square miles, including many lakes and tributary streams. The open nature of the soil and the numerous lakes in this watershed are favorable to a large and comparatively steady run-off. The lumbermen's dam backs the water up about fifteen miles, producing a considerable storage. This dam has automatic gates, which are an indispensable means of controlling the flow of the river and of increasing the flow at the power development during periods of low water by releasing the water stored by it.

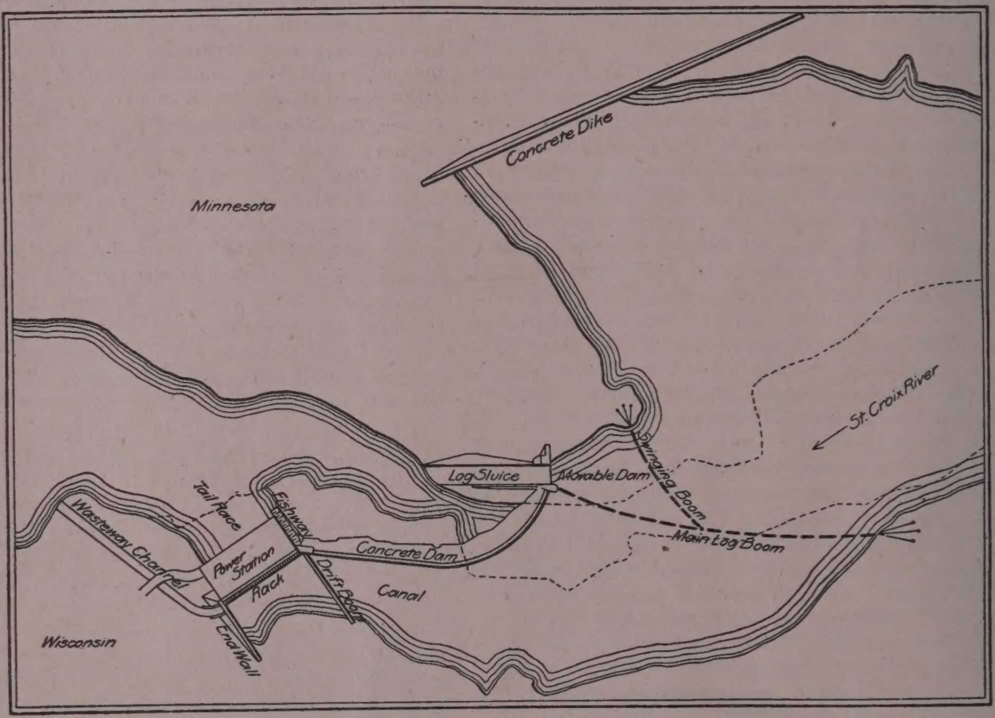
Dam.—The St. Croix dam is built at a point where the river passes between high headlands of trap rock which form an excellent site for the development. The dam is built on a trap rock and has a gravity section of cyclopean concrete. It starts across the channel from the headland on the Minnesota side and sweeps on a long curve down stream along the Wisconsin bank of the stream forming a canal, or forebay, on the latter side, with the power house at the lower end of this spillway. This plan of the dam gives a spillway 640 ft. long, which is sufficient to provide for extreme freshets without undue rise of water in the pond above. The dam produces an available head of water under normal conditions of 56 ft.; the extreme variation of head allowed for is from 48 to 56 ft., the lower occurring at times of flood when the river backs up somewhat in the tail-race.

A log sluice is built into the section of the dam at the opposite end of the latter from the power house. This dam has a steel bear-trap gate, operated by natural head of water on it, in order to allow logs to be sluiced through with the minimum loss of water. A boom built of logs is swung across the river from this sluice and guides the logs which come down the river over the bear trap, thus keeping them away from the main dam. A coarse rack is built diagonally across the head of the canal leading to the power house forebay in order to force ice and floating débris over the main spillway of the dam without permitting it to enter the canal. Finer racks provided at the penstock entrances to the power house remove whatever débris may pass the coarse racks; and a small sluice is built in the end wall of the canal at the inshore end of the power house racks to carry to the tail race such floating débris as may be taken from these racks. A fish-way is provided at the upstream end of the power house to permit fish to pass up and down the stream.

The operation of the plant during the past winter and spring has been especially satisfactory in demonstrating the value of the still water above the dam in preventing the formation of frazil ice, and the effectiveness of the boom and rack arrangements for removing slush ice from the water entering the penstocks. As a matter of fact, there has been no trouble whatsoever from ice in any form.

Dike.—A concrete dike about 900 ft. long was built across a low depression above the town of Taylors Falls on the Minnesota side of the river to protect the town at times of high water above the dam. This dike has an extreme height of 28 ft., its crest being carried well above extreme high-water level.

Power House.—The power house is built into the section of the dam along the downstream end of the latter where the rocky headland had to be blasted away to form the canal. The hydraulic apparatus is built into a section of the dam itself with the power house superstructure extending over the tail race out into the river and up over the dam on the downstream side. This superstructure is entirely of reinforced concrete. The interior of it is planned for nine bays, ultimately, each of the four bays on either end containing one generating unit and a bank of transformers, leaving the central bay for exciter units and switchboard. The present installation includes four generating unit bays, the central exciter and switchboard bay and the first of the future bays, which is now occupied by a repair shop. A separate penstock, 12 ft. in diameter, is placed through the dam for each of the main units, and two 4-ft. penstocks for the exciter units.



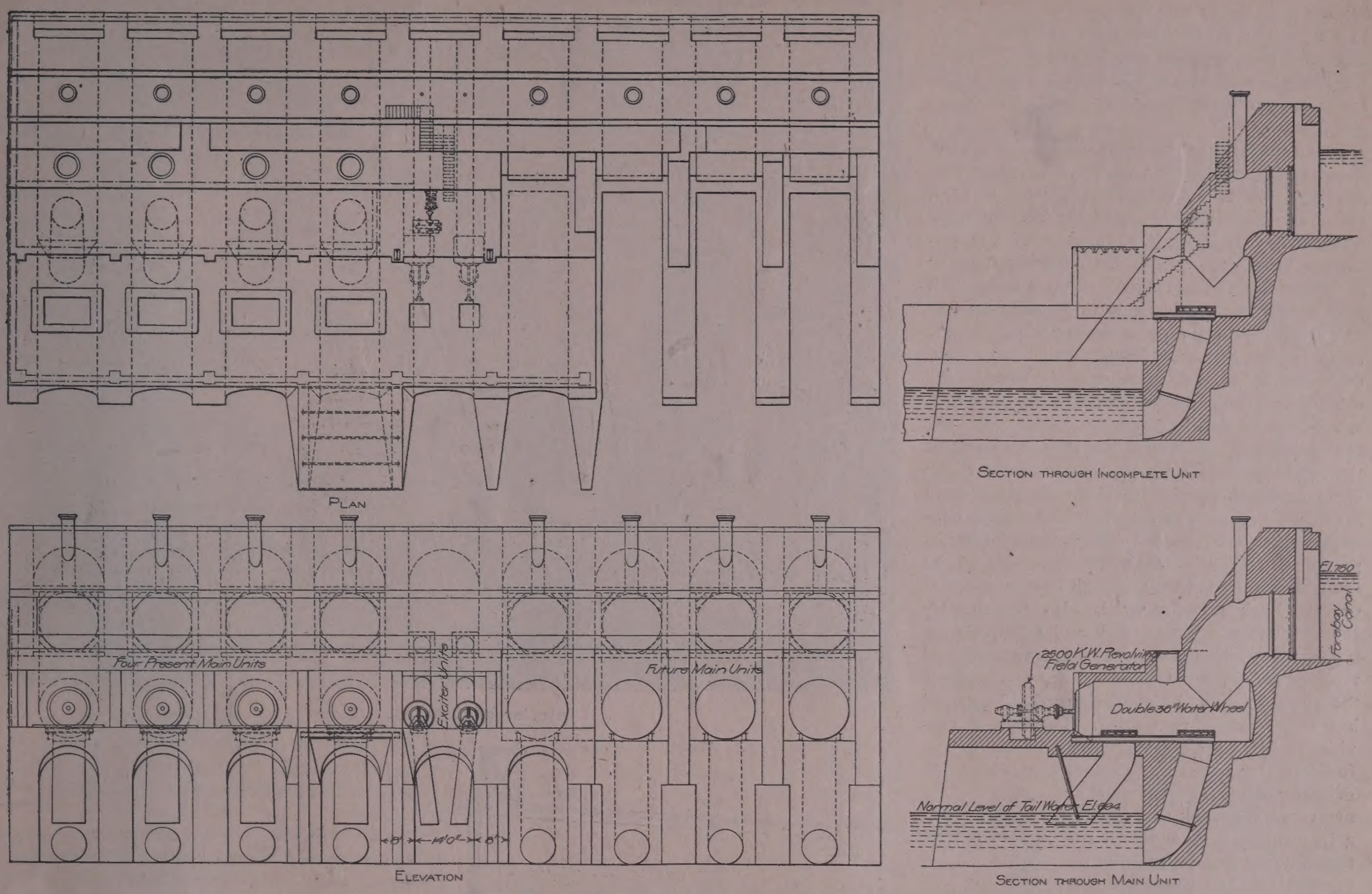
Map Showing Works of the Taylor's Falls Water-Power Development.

The distinctive feature of the arrangement of apparatus is the location of each step-up transformer bank in a separate fireproof compartment over the front ends of the penstocks, these compartments opening directly on a gallery in the generator room. This allows the transformers to be rolled out, on their own wheels, under a 25-ton electrically-driven Niles crane, which travels the length of the generator room. The heavier pieces of apparatus are all thus under the direct control of this main crane.

In the rear of the transformer rooms is a corridor with well holes leading down into the various wheel pits. This corridor is fitted with a traveling electric hoist which allows all parts of the water-wheel apparatus to be drawn up into the corridor and carried through into the repair shop in the fifth generating unit bay at the end of the present generator room.

In the open space at the middle of the generator room and between the present and future transformers is the switchboard controlling the station apparatus and lines. The board is arranged on a semi-ellipse so the attendant while standing at the gallery rail in front of the board can see all parts of the generator room and at the same time have a fair view of all the switchboard instruments. The water-wheel driven exciter units are located in the middle of the generator room below the switchboard gallery, leaving a space for a third exciter which is to be motor driven. Directly above and reaching back over the corridor above the wheel parts are two low fireproof compartments which are divided in cells for the high tension wiring, by hollow terra cotta tile construction. Above these compartments is the main switch room containing the oil switches controlling the lines and apparatus. The present transmission line leads from a tower built to one side of the main switch room and at the middle of the downstream side of the building. A steel tower is erected just outside the tower on the building, the transmission line over the tail races leading across the river from this tower. The future extension of the building will include an extension of the tower surmounting it and the duplication of the steel tower to provide for a second transmission line. The present tower in the building is of sufficient size to accommodate high tension lightning arresters, oil insulated choke coils and instrument transformers. Back of the switch room and reaching out over the top of the dam is a room sheltering the head-gate hoisting mechanism and providing space for stock room and storage. Along the canal side of this room is a platform from which the trash racks may be racked and kept clear.

Each main wheel unit consists of two pairs of 36-in. Platt Iron Works cylinder-gate Victor water wheels mounted on a shaft extending into the generator room and coupled direct to its generator. Each wheel unit is rated at 4,200



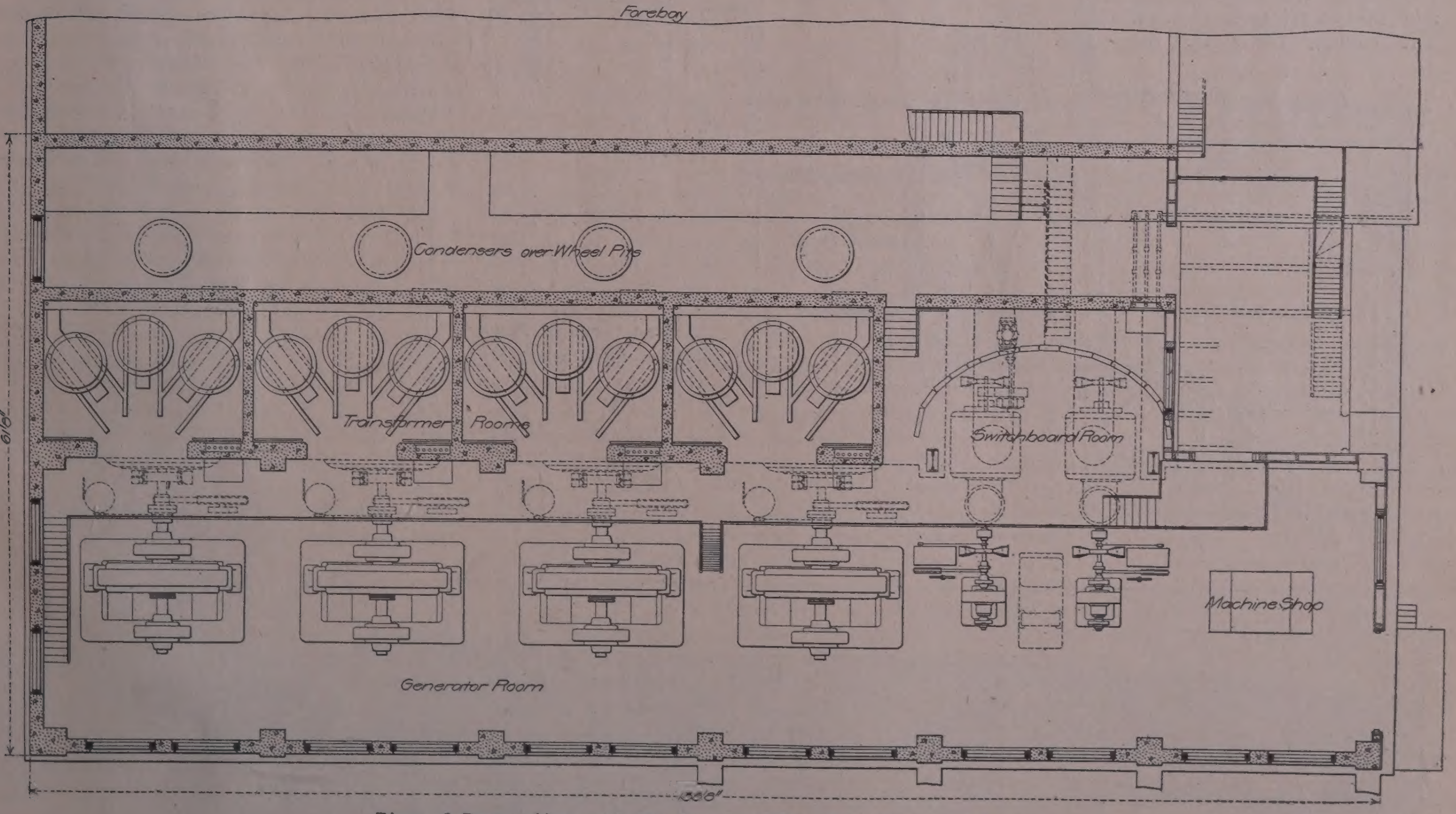
PLAN

ELEVATION

SECTION THROUGH INCOMPLETE UNIT

SECTION THROUGH MAIN UNIT

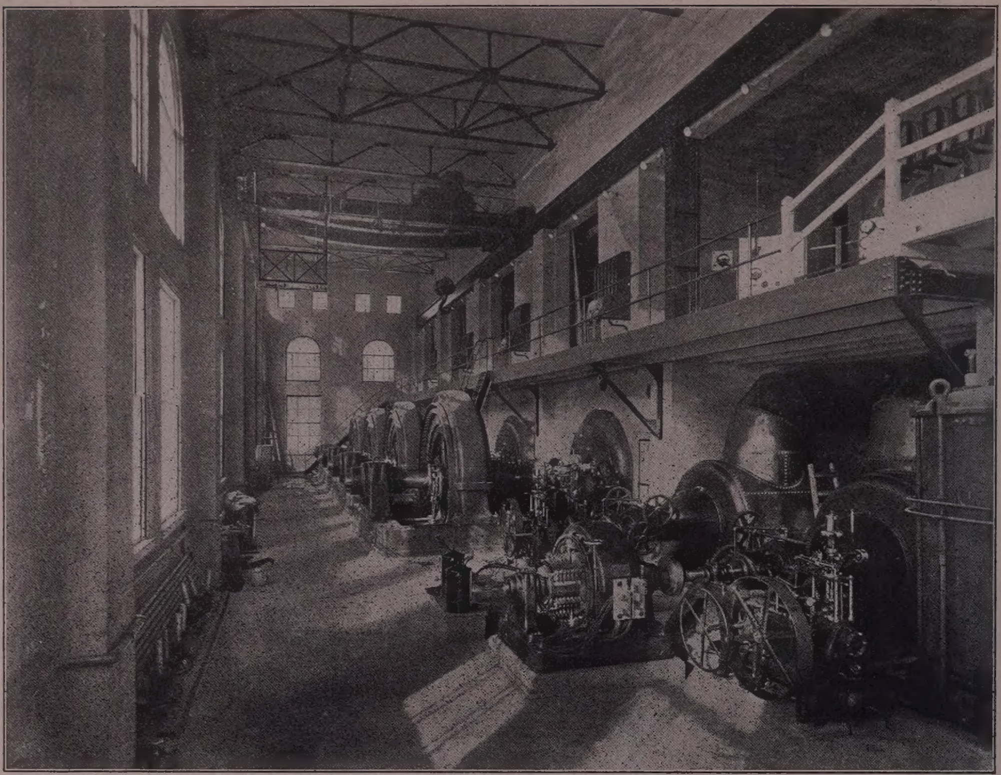
Plan, Elevation and Section of Power House.



Plan of Power House at the Level of the Transformer Rooms.

h.-p. when running at 277 r. p. m. under a head of 55 ft., and has sufficient capacity to operate its generator, at the full rated load of the latter, under a minimum head of 48 ft.

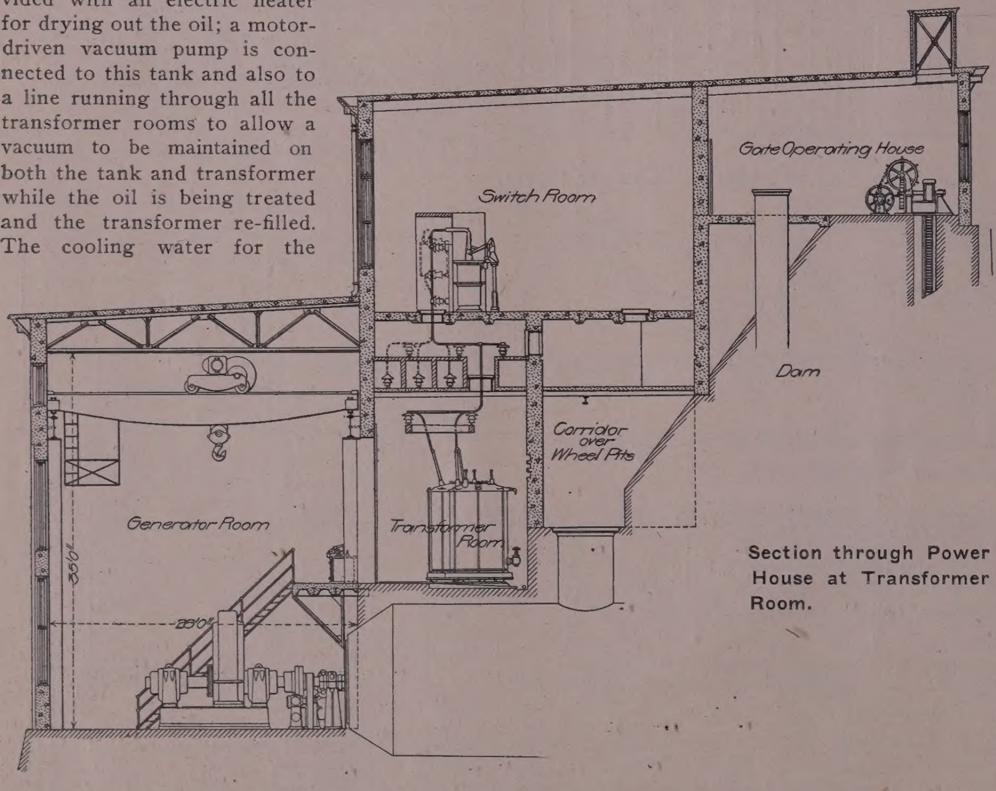
The casing of each of the main wheels is cylindrical, with the front head through which the main shaft connecting the wheel and its generator passes, brought flush with the downstream face of the dam, the latter forming the rear wall of the generator room. Water is admitted to each wheel casing through a boiler-plate quarter-turn penstock, 12 ft. in diameter, its upper end opening directly into the canal and its lower end into the top of the rear end of the flume. These penstocks are fitted with electrically-operated timber gates, which close their canal ends. Each pair of wheels of the unit is mounted in a separate case with a flaring draft tube of boiler plate, 7½ ft. in diameter at top. Each quarter-turn is provided with an air vent rising above the level of the water in the canal.



Interior of Generator Room.

Each main water wheel unit is direct-connected to a 2,500 kw. Westinghouse revolving field generator. The generators are wound Y-connected for 2,200 volts, 60-cycle three-phase current and are rated to carry the usual overloads of 25 per cent.

The transformers are arranged in banks of three, each permanently connected to the corresponding generator and operated with it as a unit. The transformers are of the Westinghouse water-cooled type, with a capacity of 900 kw. each. They are wound for stepping up the generator output from 2,200 to 50,000 volts, with taps on the low tension side to permit considerable range of ratio of transformation. While these transformers are intended to be operated on a 1 to 10 ratio, they are made in exact duplicate of the transformers in the main step-down sub-station so that by selecting suitable taps they may be adapted for use at the step-down end of the line and adjusted to compensate for the changing conditions as the load on the system grows. Both sides of the transformers are connected delta un-grounded. Each transformer is provided with a blow-off to allow oil to be drained into the tail race beneath in case of emergency. Each transformer is also permanently connected to a drainage tank and oil-circulating system by which the oil may be drawn off and replaced by freshly treated oil from a tank in the store room and the discharged oil pumped into this tank for re-treating. The tank is provided with an electric heater for drying out the oil; a motor-driven vacuum pump is connected to this tank and also to a line running through all the transformer rooms to allow a vacuum to be maintained on both the tank and transformer while the oil is being treated and the transformer re-filled. The cooling water for the transformers is taken from the canal, and is discharged into the tail races below under its natural head, after passing through the transformers.



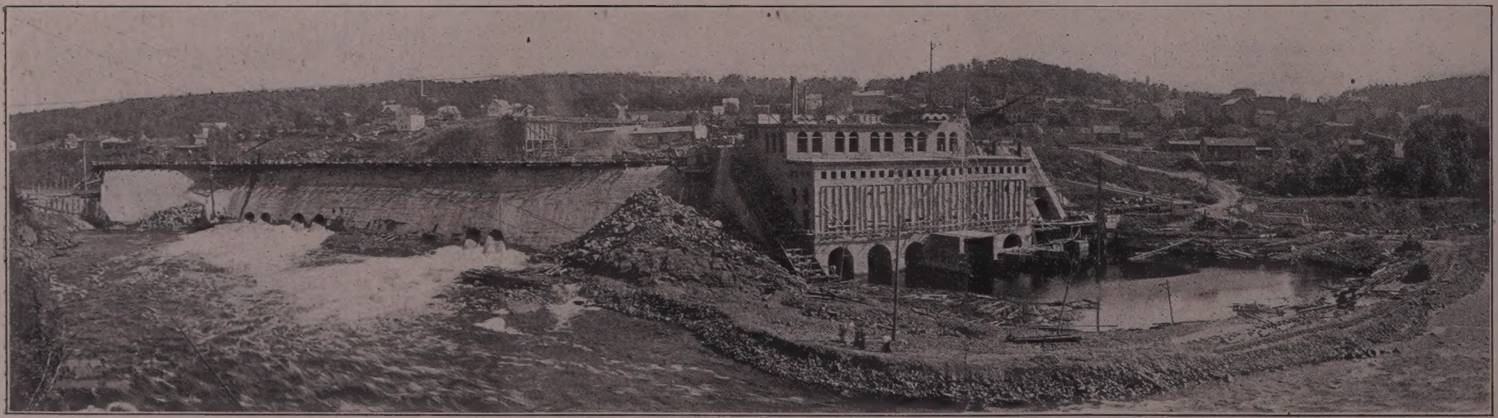
Section through Power House at Transformer Room.

The two wheel-driven exciters are Westinghouse 125-volt, 100-kw. units. Each machine is driven by a Platt Iron Works 18-in. cylinder-gate Victor water wheel of 225 h.-p. capacity when running at a speed of 500 r. p. m., under the available head. The exciters are connected to operate in parallel, or separately in case it is necessary to use one machine for operating the station auxiliaries without the possibility of disturbance to the voltage of the machine exciting the generators.

Each main water wheel unit is controlled by a Type N Lombard governor and each exciter unit by a Type Q governor of the same make.

The building is provided with a steam heating system which is used during the coldest weather to supplement the heat radiated from the generators and transformers.

The switchboard consists of panels for the generators and corresponding transformer banks, for the exciters, transmission line, totaling, station and local supply. The board is of Westinghouse make and is arranged to place in the hands of the switchboard attendant the control of the starting, stopping and speed adjustment of each water wheel, the synchronizing of generators and transformers, the control of



General View of Power House and Dam during Construction.

the transmission line and all local supply circuits, leaving the oiler on the generator room floor free to care for the apparatus.

The low-tension leads of the main station wiring have varnished cambric insulation laid in vulcanized-fibre conduit placed in the floors and walls. These leads connect through disconnecting switches to the corresponding banks of transformers and high-tension connections from each transformer bank through an oil switch to the present high-tension busses. In future they will connect through a second oil switch to a second high-tension bus to be put in when the second transmission line is built, and at that time from either of the high tension bnsses through oil switches to either transmission line.

(To be continued.)

An English Track Failure.

A track failure which occurred on the North-Eastern Ry., near Felling, England, on March 26, has been investigated by the engineers of the Board of Trade, which has recently made an interesting report concerning it. On the morning of the day of the accident there had been a sharp frost, which was followed by a calm atmosphere and a hot sun in a cloudless sky. The site of the accident is a deep cut, which kept off whatever breeze might occasionally blow, and had a southern slope on such a gentle grade that the track was not shaded. The cinder ballast probbly gave off heat by radiation. The nuts on the bolts of the fish plates were all screwed tight, as is the custom in the winter, and the track gang did not slacken these off nor go along the line in the middle of the day on the lookout for tight joints, as is the custom during the summer. Thirteen minutes before the accident occurred, another train passed over the road without difficulty. Just before the accident a man who happened to be looking at the track suddenly saw it wave into an S-shape for a length of about 2 ft. The 30-ft. rails were 84-lb. bull-headed sections resting on 9-ft. crossties, eleven to the rail-length. As a result of the accident to the train, which was derailed immediately after the rail kinked, two people were fatally injured and about 40 more or less hurt. The railroad company has since made experiments to determine the effect of heat on track under such conditions. The observations were made at each joint for a quarter of a mile on each side of the place of derailment. It was found that practically no difference existed in the width of the gaps between rails at half past six in the morning and half past one in the afternoon for two, three or four-rail lengths, at times, and that the whole expansion of these rails was taken up in a single gap. The normal gap between rail lengths, is 0.25 in. and the observations showed that this was found to be increased by contraction at times to 0.32, 0.34, 0.42, and 0.52 in. at places.

EXPOSED LIMESTONE MASONRY can be protected against the influence of impurities in the air of large cities by a method followed by Professor Church and explained by him at a recent meeting of the Royal Institution. This consists of spraying the stone with a saturated solution of barium hydrate. The solution is sprayed over the surface of the stone a number of times, and results in making it harder and denser than when it is in its normal condition. The hydrate, when it comes in contact with sulphate of lime is converted into sulphate of barium, which is practically insoluble in water, and the lime is converted into carbonate of lime by the absorption of carbon dioxide from the air. Professor Church also advises protecting the surface of the stone with ceresin wax, which has a waterproofing effect.

The Enforcement of Specifications.

Annual Presidential Address of Dr. Charles B. Dudley before the American Society for Testing Materials.

In the early days of specifications, they were little more than attempts on the part of the consumer, to tell the producer what he wanted. Some specifications which we have seen, consisted of only a few lines, and these either related almost entirely to a brief description of the material desired, or embodied some simple tests. Indeed in the preparation of such specifications, there is reason to think that the consumer himself had meager information in regard to the material he was describing, and perhaps only knew with certainty that the material he was receiving was unsatisfactory, and that he wanted something different.

Later on, as knowledge of materials increased, as methods of testing became better understood, and more completely worked out, as those who were making specifications learned by experience how difficult a matter it was to draw a satisfactory specification, and especially after it became the custom to consult the manufacturer in making the specification, it took on a new meaning. At first it was a demand; it now became an agreement. At first it was ofttimes, perhaps, promulgated with something of a feeling of superiority, by its maker, and was received by the manufacturer or producer, with a feeling of opposition and antagonism; it now became more of a compromise, and was put forth and received with a much more conciliatory spirit on both sides. From being a species of legal instrument that had in it conditions and requirements, that the one who held the purse strings felt that he had a right to insist on, it took on more the nature of a contract, in which the stipulations had practically been agreed upon by both parties in interest.

Looking at the specifications in this light, and assuming, as we must, that business to be successful, must be conducted in accordance with the principles of honesty, integrity and fair dealing, it would almost seem that it would be a waste of time and effort, to discuss the subject which we have chosen for this paper, "The Enforcement of Specifications." The specification is a contract, and, as we have said again and again, in any properly drawn specification, both parties have had a voice, differences have been harmonized, and the conditions and stipulations have been agreed upon. If now, men are honorable, and intend to do as they have agreed, as we are bound to assume that they are, and do intend to do, what need is there for enforcement? Is it not safe for the consumer to receive and put into use the material which the producer furnishes, without the trouble and expense of maintaining a department, or a corps of inspectors, to protect his interests? Unfortunately the experience of the business world at the present time, does not seem to warrant such a procedure. I doubt not there are consumers within the sound of my voice, who if pressed for an answer to our question, would say with a somewhat sarcastic smile, that the situation is utopian, and that with human nature as it is, it is absurd to expect to get what you have contracted for, unless people are watched. On the other hand, no doubt an equal number of producers who hear me, are entirely ready to assert that they are conducting their business in such a way, and are making and delivering such a product, in their specification material, that any consumer would be absolutely safe in receiving and using it without inspection. For our own part, as the result of an almost daily experience for now some thirty years, with specification material, we are compelled to side with the consumers, and to maintain the necessity for inspection and tests.

And lest by this statement, we should seem to call in question the business integrity of the producers, among whom we are happy to number some of our best and most valued friends, let us hasten to say, that there are so many conditions leading to the manufacture and delivery of unsatisfactory materials, that is, materials that do not fill the requrements of the specification on which they were bought, which conditions do not involve the business integrity, or the honest intention on the part of producer to do as he has agreed, that we are sure no one need feel aggrieved at the establishment and maintenance by consumers of devices for the enforcement of their specifications. It would, of course, lead us too far to inject into this paper, a discussion of business honesty on high moral grounds. Such a discussion is foreign to our present purpose. The basis of our discussion is the business truism, that a transaction is satisfactory when both parties get benefit from it, and both parties are satisfied. No one believes more devoutly than we do, that with few exceptions, that are so few as to be almost ignorable, producers in general prefer to do an honest business at a fair price and profit, and that they always would do so, if— it were not for certain conditions. What, then, are some of these conditions?

First, however, in order to avoid constant repetition of the words "materials according to specifications," and "not according to specifications," let us agree that the former may be properly designated as "satisfactory materials," and the latter as "unsatisfactory materials," the viewpoint obviously being that of the consumer. This being granted, the first condition that we will consider which leads to the tender of unsatisfactory materials is, improperly worded or unreasonable specifications. It is obvious that the viewpoint of those having to do with either the making or carrying out of specifications being different, and in a sense antagonistic, since their interests are naturally and legitimately opposed, the meaning which they attach to words will be different, and both parties may be equally honest. We knew of a case once, where a lumberman agreed to buy a large number of logs from the owner of a valuable timber tract, on the simple specification that only two logs from a tree should be delivered. Imagine his surprise when the logs began to come in, to find them small, tapering, and full of knots. On remonstrating, he was told that just exactly as the specification called for, only two logs per tree were being delivered, and he was invited to look at his contract. An inspection revealed the fact that although the lumberman undoubtedly had in mind when the specification was drawn that he should receive two logs from the butt of each tree, the important word "butt," had been left out; while on the other hand, the owner of the lumber tract had unquestionably read into the specification when it was presented, that under it he would be entitled to deliver two logs from the top of the tree, just as he was actually doing. It may not be unwise to add that a contract covering two butt logs from each tree, was somewhat unusual, that the price was lower than would have been expected for such logs, and that as a matter of fact, the case never came into court. In like manner an unreasonable requirement in a specification, may lead to the same result. Our friends, the steel manufacturers, are constantly being presented with specifications containing stipulations which it is impossible or at best, only occasionally possible to fill. Those who have made these specifications, have, it is true, we fear, neglected one of the prime requisites of a good specification, viz.: to consult with, and on certain technical points, be guided by the best manufacturers. And, further, it may be urged, that a producer has no right to take a contract under a specification that contains a requirement that he knows he cannot fill. While this is true abstractly, it must be remembered that the producer is in a rather delicate situation. If he remonstrates against the unreasonable requirements, he probably loses a customer. If he refuses to take the contract with the unreasonable requirement, and, as a matter of fact, it is well known that this is done again and again, he not infrequently makes an enemy of the engineer or expert, who simply has a crotchet in his head, but is otherwise a very good fellow, and who later, may be valuable, and so the contract is taken, even with the unreasonable requirements, and with the thought in mind of getting along with the matter in the best way possible, if any difficulty should arise. The producer, we fancy, knows that he is making good material and giving good value, and with this thought condones himself for his seeming breach of contract. As far as our subject is concerned, we cannot but feel that an improperly worded or an unreasonagle specification, is a most potent cause for the tender of unsatisfactory materials.

Again the mistakes of subordinates are a frequent cause for the same difficulty. An illustration of what we mean by mistakes of subordinates will make the matter clear. Some years ago a railroad company placed an order with a most reputable firm for fifty barrels of the best grade of lard oil, known at the time as "Extra" or "Prime," the other well known grades being Extra No. 1, No. 2, and No. 3. The difference in the cost of the extreme grades was ten to fifteen cents per gallon. The order was what is technically known as a "Rush" order, that is to be filled as soon as possible. In due time the material arrived at destination, and was sampled and tested in the regular way. The test showed the material to be No. 3 oil, and the shipment was promptly rejected and returned to the shippers. They made a careful examination of the shipment barrel by barrel, and found that 45 barrels contained oil of the proper grade and of unexceptional quality, while the five barrels were No. 3 grade as the test had shown. On asking for an explanation, the foreman of the works said that when the order was received he only had 45 barrels of the proper grade in stock, and being a rush order, he put in five barrels, which he knew to be inferior, hoping that the matter would escape detection.

It may be of interest to know that in this case the shippers actually felt themselves aggrieved, and claimed that since they had to pay return freight on rejected material, the 45 barrels of good oil should have been retained, and only the five barrels of inferior oil should have been returned. The Purchasing Agent, on the other hand, very mildly, but very firmly reminded the shippers that the order which he had placed with them did not call for any No. 3 oil, that there was a difference in price of at least $5.00 a barrel between the two oils, and that if perchance the sample tested had come from one of the barrels of good oil, the shipment would have been accepted without question, and it would have been a clear case of successful fraud, by which they would have profited. But there was considerably more in this case than was brought out by the Purchasing Agent. Extra or prime lard oil is used by railroad companies almost exclusively in making what is technically known as "Signal Oil," that is, oil used in signal lights, and in trainmen's lanterns; also the safety of trains and even the lives of passengers depend on the reliability of the signal oil, and perhaps more important still, a signal oil made of No. 3 lard oil, is utterly worthless and unreliable. The lanterns will commonly go out and fail completely within two hours after new trimming and filling with such oil. The bearing of all this on the necessity for the enforcement of specifications is too evident to require comment.

It would lead us wide of our proper field to raise and discuss the question whether such a mistake on the part of subordinates, as we have cited, is ever made with the knowledge and consent of the principals or not. We have heard it intimated that such transactions are fairly common, and that when such a case comes to the knowledge of the office or the principals, one of two things is apt to result. If the shipment has gone through, the transaction is closed, and no questions have been raised, the subordinate is usually not reprimanded, but on the contrary gets a smile of approval. On the other hand, if the fraud is detected, and trouble and loss result, the subordinate not infrequently suffers.

Perhaps you will bear with me while I give another out of the many that might be cited of the conditions leading to the tender of unsatisfactory materials, even though those who are doing so have a sincere and honest intention of fully meeting the requirements. This condition is that commercial processes do not always yield what is expected of them. Something in the materials used, or in the processes employed, gives a product that is unsatisfactory, notwithstand the producer supposed he had done everything that he could to secure a successful result. Let me give an illustration: Some years ago in our laboratory at Altoona, we examined in the regular way a sample representing a shipment of phosphor-bronze bearing metal, from a firm whose business reputation and character were simply above reproach. This material, as is well known, is an alloy of copper, tin, lead and phosphorus, the percentages of each constituent being fixed within narrow limits, by the specifications. The analysis showed copper, tin and lead within the limits, but no phosphorus, and the shipment was rejected. This was followed by a visit from one of the principals of the firm, who maintained that he had actually purchased in the market phosphor-tin at a high price, and used it in making this very material, and that the fact that we found no phosphorus was a mystery to him. It was asked if he knew by analysis how much phosphorus there actually was in this so-called phosphor-tin, since our own analyses of the material in the market, showed not over a third or at most half of what was claimed. He confessed that no analyses had been made, but stated that he bought the material on a guarantee that it contained ten per cent. He was then asked if he knew that there was a loss of phosphorus every time the alloy was melted, and that with careless foundry manipulation this loss might readily amount to all the phosphorus he had actually added. His reply indicated haziness on the subject, coupled with a desire to learn. A few suggestions were eagerly noted, and apparently well applied, since the same firm subsequently made and furnished to the road large quantities of entirely acceptable material.

And so we might go on quite at length, detailing condition after condition, that leads to the tender of unsatisfactory materials, some of them perhaps not quite as free from suspicion as those already mentioned, but all of them emphasizing the necessity on the part of the consumer, of apparatus and appliances for testing, and a rigid enforcement of specifications. It will perhaps be sufficient if we enumerate without special illustration or comment, a few more of these conditions. A contract taken at too low a figure is a fertile cause of what we have agreed to call unsatisfactory materials. Under stress of competition agreements are made that if carried out strictly in accordance with the specifications, would result in loss, or lack of reasonable profit. Again, strange as it may seem, a very large number of manufacturers of commercial products, as a matter of fact do not know the characteristics of their output. They have been making and selling their staple for a period of years, it may be, and as long as the consumers accepted the material, and raised no questions, they themselves saw no need of making tests and experiments, except perchance such as would lead to diminution of cost in manufacture. Accordingly very little or no knowledge was obtained of those qualities of the material, which are of most interest to the consumer. It has been our custom for many years, as is well known, to send our proposed specifications to the manufacturers for criticism before they are officially issued, and we have again and again received from producers in reply to the question whether they could make a product that would stand the tests of the proposed specifications, the answer, that they could if anybody could. There was apparently absolute lack of even the most rudimentary knowledge of those qualities of their product which were of the most interest and importance to the consumer. And yet, without this knowledge, contracts are taken and shipments made. What more natural than that the material should be unsatisfactory in the technical sense of the word? Again the tender of unsatisfactory material is often explained after it has been tested and found wanting by the statement that although it may not quite fill the requirements, it still is good material and will do the work. Of course it takes but a moment's reflection to lead any fair minded person to the conclusion, that this statement is not at all the question at issue, and that if the consumer had been willing to use a material that is, in the language of the shops, "just as good," he would have specified such material, and obtained the benefit of a corresponding variation in price.

Two more conditions leading to unsatisfactory materials may perhaps wisely be mentioned, before we leave this phase of our subject. It not infrequently happens after a contract has been made that unexpected and wholly unforeseen difficulties arise in securing raw materials from which the product in question is made. An unexpected demand has sprung up for that kind of raw material, making it scarce in the market, or the parties with whom the producer has a contract for his supply, repudiate the contract, or there has been an accident or catastrophe affecting the supply. The producer therefore finds himself in the condition that either he is unable to make deliveries as he has agreed to do, or he must, or thinks he must, make deliveries of his product containing such raw materials as he can get, with the accompaniment of that brood of troubles that arise when the tests show unsatisfactory materials. Not once, but many times, has this situation been prominent in the course of our work at Altoona; and there is one phase of the matter which we have found it most difficult to understand. The producer goes ahead and makes up his product from inferior raw materials, and makes shipments, knowing that there will be trouble; and then when the trouble arises he explains and asks for leniency. The query in our minds has always been, why does he not explain and ask for leniency before he makes and ships the unsatisfactory material? If we may trust our experience, a frank statement of the situation beforehand, would be far the wiser course. We fancy the reasons for the procedure actually followed will ever remain one of those business mysteries which are incomprehensible to the lay mind.

Finally a most common and pestiferous cause of the tender of unsatisfactory material, is the statement that delay must follow if these unsatisfactory materials are not received and used. We say pestiferous, because of all the causes leading up to the tender of unsatisfactory materials, this one seems to us to have the least foundation of equity to rest on, and to be the one that smacks most strongly of a deliberate effort to force through an acceptance, regardless of quality. We are quite well aware that emergencies may arise in the case of those who are furnishing materials, which emergencies may fairly be regarded as legitimate causes for an unsatisfactory product. We have already discussed a number of such. On the other hand we have so many times had occasion to feel that at the last minute, materials are tendered, which the parties had known for some time, or at least might have known, were inferior and not satisfactory, that the argument, that there will be delay if you do not accept this that we tender, is deprived in our minds of a very large percentage of its force. It would be infinitely better, it seems to us, not to make shipments, and either to put some of the energy now employed in trying to get unsatisfactory shipments accepted, into making and furnishing satisfactory material, or to make a frank statement of the situation to the consumer beforehand, and abide his decision. Such a statement would do much toward smoothing down and removing some of the roughnesses and inequalities of the road which the producer and consumer are trying to travel together toward the goal of a successful financial transaction.

Let us now turn to another phase of our subject. If we have succeeded in what has been said, it is evident that there is necessity for the enforcement of specifications, and that, too, without assuming that men are dishonest or do not intend to do as they have agreed. Under present commercial conditions, and with our present knowledge of the properties of materials and of the processes by which they are made, it simply would not do for the consumer to leave his interests wholly in the hands of the producer. Each must look out for his own interests, and be prepared to defend and maintain them. Perhaps we have said more than is necessary on this point, but the practice of buying and using materials on the reputation of the maker is so deep-seated and widespread, and has for so many years been the refuge of engineers in cases of failure, that perhaps the subject will safely bear elucidation at a little greater length than would otherwise have been admissible.

But how shall specifications be enforced? What are the essentials of successful enforcement? We reply, first, the examination and testing of the material tendered must be so planned as to be efficient and leave no loophopes for evasion or substitution of inferior materials. In the case of some substances, every shipment must be tested. In the case of others, as for example, materials that are produced in heats, or are stored in tanks or bins, the tests deciding their fate may be construed to cover the whole amount even though there may be a number of deliveries. The essential feature is that each test or lot of tests shall cover a definite amount of material, and that nothing shall be left to the honesty and good intention of the producer or shipper. If we are going to trust the producer in one detail we may as well trust him in all. The strength of a chain is the strength of its weakest link. No universal rule can be given, but assuming that the specifications is wisely drawn and provides only essential tests, these tests must be so applied as reasonably to cover all the material that is delivered.

Again, since it is clearly impossible, except perhaps, in the case of proof strains, to apply tests to all the material in the shipment, it is obvious we must rely on tests of samples, and this brings up the question of sampling. Upon this point several rules are clearly applicable. First, a representative of the consumer must always take the sample. This is in accordance with the principle already enunciated, that it is not reasonable or proper or safe to trust the producers in anything by which the validity of the tests might be affected. Not once but many hundred times have we been asked to allow the shippers or producers to send a sample and accept a shipment on its examination. The request was undoubtedly made in good faith, and with no other desire than to facilitate the transaction. Perhaps it is needless to say that our belief in the facility with which unintentional mistakes would be made, and a sample better than the average of the shipment be sent, has always led us to positively refuse such requests.

Second, the sample must be representative of the whole shipment or lot under test. This point is usually provided for in the specifications and does not here require special comment. Nor is it essential perhaps to remark on the necessity that the sample should represent a definite amount of material, since this is also provided for in the specifications. We may, however, be permitted to say that some specifications that we have seen seem to us to assume greater uniformity in the product made in successive similar operations than actually exists in the material. If it were at all possible to avoid it, we would not like to accept articles of steel made by the Bessmer process, especially where strength and safety are involved, without a test of each blow.

A third point in regard to sampling has a more direct bearing on our theme, the enforcement of specifications, viz.: the sample should be taken at random, and not always from the same place. We have many times been surprised to find out how intimate the knowledge on the part of the shipper or producer soon gets to be, of the practices of the consumer in sampling. Apparently the producer thinks it is just as fair that he should know all about the consumer's use of his material, as that the consumer should know all about his manufacture of it. And this we are quite ready to concede. But now if in sampling a car load of oil, the barrel next to the door is always chosen by the inspector, or if in sampling a pile of axles, the one on top is always selected, or in picking out a spring for test from a lot assembled and offered, if the one nearest at hand is habitually taken it is perfectly evident that an opportunity is afforded for one of those unintentional mistakes of workmen or foremen that would result in the best material always being tested. It would take us too far away from our subject to discuss here the bearing upon these unintentional mistakes of the practice which is so common in many establishments of paying the subordinates, nay, even the whole manufacturing organization perhaps in proportion to the amount of successful output. We cannot but think, however, that ingenuity in sampling is a legitimate and reasonable offset to this practice, and that it is as important that the inspector who takes the samples should be full of suspicion and scientific doubt, as that testing machines should be reliable, or that a chemical balance should give accurate weights.

As showing how failure to comprehend the whole shipment in the sampling may result in disaster, and at the same time illustrate the unintentional mistakes of workmen, about which we have already said so much, let us cite an incident. A lot of bronze castings were being furnished for use in locomotive construction. The order was a large one and shipments were made from time to time. The inspection force was pressed with work, and let it be confessed, not quite as much permeated with suspicion and scientific doubt as should have been the case. The bronze was bought on definite chemical specifications, and from each delivery, enough sprues were broken off from various castings by the inspector, to properly sample the material. These samples were used for the analysis. Deliveries were made usually about three times a week, and the inspector was sent for to inspect and sample the material whenever a delivery was ready. It was explained to the inspector that it would greatly facilitate the work of the foundry if he would allow, say, three-fourths or more of the castings to have the sprues broken off and used over again before the regular sampling was done. They would leave enough sprues attached, say to a quarter of the castings (nothing very definite as to the number of sprues to be left attached was promised) so that he would have abundant chance for selection. In the goodness of his heart, the inspector allowed this to be done. A number of shipments were made, sampled, tested and accepted in this way. Some suspicion having arisen later in the minds of those higher up than the inspectors in the testing organization, some twenty full size casting, all selected from a large number of those from which the sprues had been broken off before sampling, were sent for analysis. The analyses showed that in some manner not explained, every one of the samples from the castings bereaved of their sprues by the foundry force were not only not according to the specifications, but showed unmistakable evidence of having in their composition large percentages of inferior scrap. It is perhaps needless to add that from this time forward after the inspector had been changed the sprues were all allowed to remain on all castings until the sampling was finished.

This brings us to the last requirement in sampling which we will discuss, viz.: the sampled material should, as far as possible, not remain in the hands of the producers after it has been sampled. The equity of this practice will not, we fancy, be called in question; the actual carrying out of the rule is not always so easy. Materials that are sampled and tested after they arrive at destination, present no difficulties. We have known of refusals to ship, until after the material had been tested and accepted, but when it was explained that it would be practically impossible to send inspectors to sample every shipment of every kind of material before it was started on its journey to the service for which it was intended such refusals have usually vanished. Moreover, the refusal to ship has always seemed to us to argue either a lack of knowledge of the characteristics of the material that the shipper is tendering or a well grounded fear that it would not stand test. Also in the case of materials, such as springs, alloys, etc., which can be inspected and sampled and then loaded at once, there is no difficulty, but in the case of materials which cannot be so treated or which must be stored, the matter is more serious. In such cases, marking in such a way that the marking cannot be defaced without showing it, must always be practised. The chances for unintentional mistakes are too numerous, and the fact that such mistakes do actually frequently occur, is too common to permit of any uncertainty on this point.

Before leaving the subject of sampling, perhaps you will bear a word on the question, whether a sample taken with all the known precautions, does as a matter of fact, actually represent the shipment. The sample is but a very small fragment of the shipment, and a doubt fairly may be felt, as to whether the whole shipment is like the sample. It is obvious that if the specification is intelligently drawn, all the variations in the material, due to uncertainties in the process of manufacture, or unavoidable errors of manipulation are provided for in the sampling which it directs. This leaves only intentional or unintentional variations, introduced by the producer, to be provided against. Our position in regard to these has always been that if the producer was willing to take the risk of our getting our sample from one of these intentionally inferior parts of the shipment, with the rejection which would inevitably follow, we were willing to take the chance of getting a sample from a better part of the shipment, with the consequent acceptance of some inferior material. Moreover, in cases of reasonable doubt we have a number of times sampled every part of a shipment, and are strong in our belief, that very few commercial men would persistently offer material, portions of which they knew to be inferior.

But, again, let us discuss another phase of our theme. Let us assume that the specification has been wisely drawn, that a shipment has been properly sampled, and that the tests show that it does not fill the requirements. What is the next step? As a matter of fact in our own daily work, but one thing is ever done, and that is, the material is rejected. None of our specifications provide for a second or third sampling and corresponding tests. Our theory is that the material ought all to be of the grade called for by the specifications, since this is what the consumer has bargained for, and if this is the actual fact, one sample is as good as fifty. We are quite well aware that there are many specifications in force, which provide for second, and if need be, third tests, the fate of the shipment to be decided by the majority. But this has for a long time seemed to us to be a survival of the crude early days of testing, when neither producer or consumer knew much about materials, and which it is high time should be banished forever. If a specification is so severe that only two-thirds of well made material will stand test, the specification should be changed, and if a manufacturer can only make a product two-thirds of which will stand test, he should either learn how to improve his product or go out of business. Testing was never intended to be a device to bring about the acceptance of inferior material; but quite the contrary. Moreover, from three samplings and tests, it is but a step to five or seven or nine, and perhaps if sampling and test is long enough indulged in, a majority may ultimately be found which will always bring acceptance of the material. Surely the interests and responsibilities of the consumer cannot be trifled with in this manner.

But, some one says, are you so sure that you are right in your single test, that you feel that you are on firm ground in rejecting material, and cutting off all chance for further tests? We reply, that is quite another matter. Retesting because the material fails, no question being raised in regard to the reliability of the tests, is entirely different from a retest because there is reason to think there is something wrong with the sampling or testing. In this case the burden of proof is on the producer, and it is incumbent on him to show reasonable ground for reopening the case. On the other hand, it is equally essential that the consumer should welcome the investigations of the producer; should throw everything open to him, and give him every facility for satisfying himself that no injustice has been done. There is no room for a Star Chamber in the enforcement of specifications. In our own laboratory, we always keep the sample of every rejected shipment, for a month, and are always ready to give the producer half of our sample for verification purposes. Moreover, we have often said to shippers who were interviewing us over rejected material, "you may follow your material from your works to destination, you may see the sampling, may follow the sample to the laboratory, and either by yourself or your technical representative be present and watch the whole operation of the testing, and finally, here is half the sample on which we have worked. Put it in the hands of any reputable chemist, and if he does not confirm our results, we will take up the question with him, and find out who is in error." Our sincere desire is to get at the truth, and we cannot put it too strongly, there should be nothing unfair or secret or arbitrary on the part of the consumer, in rejecting material. On the other hand, the sampling and testing being fair and honest and reliable, there should be but one sampling and testing and no retests.

Closely related to the point we have just discussed is the question of the use of rejected materials. It is safe to say that hundreds of times during the past thirty years, we have been asked, "Yes, it is true the material does not quite stand tests, but cannot you accept and use it?" And only a little less frequently the same request has been made of those higher in authority in the organization. The arguments usually used are, "the material will give you good service, not quite as good as if it had stood tests, but still, on the whole, fairly satisfactory." Also "we are good friends of yours, and would do the same for you." And still further "we are very large shippers over your line, and think some concession is due to us in view of this fact." There is apparently completely failure on the part of those using these arguments to comprehend the position in which they are placing the officer to whom these requests are made. Let us see if we can look at the matter from his point of view. It takes but a moment's reflection on the part of any fair minded person to enable him to see that to grant the request means a complete breaking down of the specifications. The officer in question is usually responsible for the specification. He has made and issued it, and that, too, after careful consultation with those who are to furnish the material. The requirements of the specification have been agreed to, and a contract has been made with the purchasing agent, or other officer, to furnish material that would stand test. If now the specification is to be waived in one case, why not in all, and what then becomes of the specification? Still further, a shipment of the kind in question once accepted becomes a precedent for the next case, and so on ad infinitum. Moreover, apparently, also another and very important point is forgotten, viz.: It is simply unfair and unjust to those who are furnishing material which does fully meet the requirements, to accept shipments from others who fail in this respect. Much of the obloquy which is so rife at the present time, affecting those in authority in large organizations, using large quantities of material, is legitimately and reasonably based on cases of this kind. It is claimed, and as it seems to us justly so, that certain parties have a pull and are able to do business with the organization in question, while others who are striving to be absolutely straightforward and honest, and to do as they have agreed, are entirely unsuccessful. Moreover, there is another phase of the case. It may chance that the rejected material is of such a nature that the use of it would only involve a slight financial loss. This point we will refer to in a moment. But, again, on the other hand, the rejected material may be of such a kind that the question of safety to passengers, or risk to human life, is involved in its use. In this last case, it seems to us that there can be but one answer to the request to use unsatisfactory material, and that is, "nothing could induce us to accept and use this material." And in the case where only a money loss is involved, as has just been cited, we are clear that there is only one condition under which it is at all admissible to accept and use rejected material. It has been a puzzle to us, how completely manufacturers and shippers lose sight of this condition. If among the arguments used to get the rejected material accepted, the shippers would only urge, "it is true the material is not quite what we have agreed to furnish, and in view of this fact we will deduct a certain amount from the bill," their case would, as it seems to us, stand on firm ground, and might have a reasonable expectation of success. Fairness and the ultimate satisfaction of both parties to a transaction is the only basis upon which successful business can be continuously carried on.

This whole matter of multiple tests, retests, and the disposal of unsatisfactory material can, as it seems to us, be summed up in a few words. Multiple tests are pernicious and should be abandoned. Retests, including the sampling, should never be made unless there is reasonable evidence to think there is an error somewhere in the first test, and to decide this point every reasonable facility should be furnished by the consumer to the producer, to enable him to satisfy himself. Shipments of material once fairly rejected should never be accepted and used if the material is of such a kind that safety or risk to human life is involved, and finally, it is suicidal, and brings with it a train of almost unmanageable subsequent conditions, to accept rejected material in which only commercial considerations are involved, unless there is some abatement in price.

A number of other points involved in the enforcement of specifications might be discussed, but I fear I have already wearied you. Perhaps you will bear with me while I very briefly touch upon one or two more. It not infrequently happens that when the tests are applied to the sample it is found that it almost but not quite fills the requirements. What should be the procedure in such a case? The answer is not quite as easy as might seem at first sight. It is well known that the ruling which prevails in many locations, especially abroad, is that the material fails and should be rejected. For example, suppose the specification requires not above 0.040 per cent. of prosphorus in the steel, and the analysis shows 0.043 or 0.045 per cent. . Shall the material be rejected? It is plain that the accuracy of chemical work is involved. Now it should be confessed openly and plainly, that no test gives absolutely accurate results. One of my old instructors used to say, "no chemist can make an absolutely accurate analysis." "Even though the chemist himself was infallible, the methods will not give absolute results." "There are chemists who can work near enough to accuracy so that their results are useful, and there are others who cannot." And the same is true of physical tests. Testing machines are not absolutely accurate, and strictly accurate measurements are very difficult to make. How, then, shall these inevitable inaccuracies be handled?

In our own laboratory no shipment is ever rejected until the test has been duplicated, and sometimes three or four tests are made. But this still leaves the unavoidable small inaccuracies unprovided for, and they must be provided for in some way, as not rarely acceptance or rejection turns upon them. Two ways of meeting the difficulty have been suggested. One is to have it a part of the specifications, and to have the producers clearly understand it, that the limits of the specifications cover the inevitable and unavoidable errors of testing; that is, the manufacturer should work far enough within the limits of the specifications, so that the inevitable and unavoidable errors of testing, would never lead to the rejection of a shipment. The other way is to make the limits of the specification sufficiently narrower or wider, as the case may be, to cover these unavoidable and inevitable errors of testing, and then allow for them in deciding whether to accept or reject. The latter procedure is the one we have always followed in our laboratory. An illustration will make the whole matter clear. For certain purposes, steel containing 0.040 per cent. of phosphorus, will give us perfectly satisfactory results in service. But, knowing as we do, that chemists will differ, and that there are inevitable and unavoidable errors in the analysis, we make the upper limit of phosphorus in the specification 0.03 per cent., knowing that such steel can readily be obtained in the market without undue hardship to any one. It is evident we have by this procedure sufficient margin to cover inevitable and unavoidable errors in the determination, without raising questions which involve contention and hair splitting. It is infinitely better, it seems to us, to so draw the specifications that the service will be protected by a sufficient margin to afford good strong fighting ground and then when a rejection is made, stand by it to the bitter end. One of the most used rules of our laboratory is, never reject a shipment unless you know beforehand, that so far as the figures of the test are concerned, you will win in the contest which may follow the rejection.

Again, let us suppose that a shipment has been wrongly rejected, and that the shipper has been put to expense in regard to it. Is any requital due him for this loss, or must he regard it as one of the inevitable expenses of doing business? We answer unhesitatingly that in the case supposed there is only one thing to be done, and that is for the consumer to make good the loss due to the erroneous rejection. It is a poor rule that does not work both ways.

We should like to discuss several points further in connection with our theme, notably, What shall become of rejected material? How far has the consumer a right to protect himself against such material, and especially has he a right, and is it good policy for him to so mark rejected material that it cannot be offered again? Still further we should like to bring before you the question as to who shall make good the annoyance and frequent money loss which are experienced by the consumer due to rejected materials. It is always annoying and often necessitates expensive delays and rearrangements to reject a shipment. Also what penalty, if any, should the producer pay, to requite the consumer for this annoyance and loss? Our subject is not nearly exhausted, but we have already taken too much time.

Bear with us while we conclude by presenting very briefly a problem which has had lodgment in our own brain for quite some time now, and which recent events in regard to certain materials have seemed to force into prominence. It is plain that in using materials in those constructions which involve safety in the railroad sense, or risk of human life in the public sense, there is a question of responsibility involved. If rails are defective and break, if an accident with loss of life results from the use of poor material in car construction, if a bridge falls and produces a disaster due to inferior materials, or a building collapses from the same cause, it is clear that some one should be held responsible; and since there are but two parties involved in the materials, viz.: those who make them, and those who accept and use them, it is difficult to see how one or the other of them is going to escape the responsibility. Now, our problem is, which of the two in equity, should be held responsible? It is perhaps hardly wise at this time to attempt a definite answer. Much might be said on both sides, and probably no two persons, certainly neither of the two parties most interested, would give the same answer. But there is a phase of the case which we would like to present. It is well known that in the earlier structural work, when safety was involved, there was no testing worthy the name, and materials were bought and used on the reputation of the maker. Fortunately the construction in most cases had a high factor of safety. When disaster did come, if it was due to defective materials, it was explained that the materials used were from those of the highest reputation in the business, and that no one could really be held responsible. But at the present time conditions have changed. The knowledge of the properties of materials of construction has increased, methods of testing and testing appliances have grown up in delightful profusion, and it is to-day entirely possible, we feel safe in saying, for an engineer to be reasonably sure that defective material does not go into his structures. We waive here the discussion of commercial considerations, as affecting the use of materials. If it is shown that these have led to the use of defective materials, the moral responsibility for loss of life must certainly go to the one who has allowed commercial considerations to have such undue weight, be he either the maker of the material, or the one high in authority, who has allowed it to be used. But the point we want to make is, in view of present knowledge, and present means and appliances for testing, are engineers or their principals any longer entitled to offer as an excuse for defective materials, that they were bought from the best makers? Can they equitably do so? Can they legally do so? Is not the time near at hand when engineers and their principals will be compelled, if not legally, then by force of public opinion, to acquire by the establishment of laboratories and means of testing, by the making and enforcement of specifications, such knowledge in regard to the materials they are putting into structures as will give the public greater security than it now has against disaster.

A South Carolina Decision Regarding the Use of Patent Pavements.

Patents on paving materials and methods were before the South Carolina Supreme Court in Dillingham v. City of Spartanburg, a taxpayer's suit to enjoin the execution of a pavement contract by the Southern Bitulithic Co. The specifications for the work permitted bids for brick, bitulithic or bituminous macadam or asphalt block. After they had been opened, the City Council instructed its contract committee to see if more favorable terms could not be secured from the two lowest bidders, for brick and bitulithic pavements respectively, and on the latter type obtained a considerable reduction. This made it the lowest figure offered, and it was accepted. The plaintiff in the case claimed, among other things, that the city had no power to contract for the use of patented articles in improving the streets, as it tended to create a monopoly and destroy competition. The articles referred to are the Warren compositions used in making bitulithic pavements. The court decided, however, that plenty of competition existed in the specifications for the paving work, as they did not require it to be of the bitulithic type. Furthermore, the City Council secured from Warren Bros. in advance of the opening of the bids, an agreement to furnish their patented materials to any bidder at a fixed price, together with an explanation of the methods of using them. The court was of the opinion that a municipality should not be denied the right, for the benefit of its citizens, to avail itself of useful inventions and discoveries protected by patents. The court held that when a city, exercising its power to make public improvements, in good faith decides to contract for the use of patented articles, there is created no monopoly and no abatement in competition beyond what necessarily results from the rights and privileges given the patentee by the federal government.

AN UNUSUAL PUMPING PLANT forms part of the water-works of Casino, New South Wales. A well 10 ft. in diameter and 55 ft. deep was sunk 200 ft. from a river, from which the supply is drawn through a 12-in. iron pipe, its intake end being supported on a timber staging and fitted with a movable arm and screen. The water is delivered by a four-stage centrifugal pump in the bottom of the well, provided with a vertical shaft driven by a 30-h.-p. steam engine. The water is discharged into a concrete reservoir, 139 ft. above the pump and 3,700 ft. from it, through a 6-in. force main, so that the total head against which this pump works is quite high for a capacity of but 250,000 gal. daily.

Removing a Historic Bridge.

For many years the New York, New Haven & Hartford R. R. has crossed the Westchester River near 175th St., in the Borough of the Bronx, New York, on what is claimed to be the first four-track swing bridge ever built. It has a 160-ft. span and is made with three continuous plate girders supported on a turntable 60 ft. in diameter. It is about to be replaced by a six-track Scherzer rolling lift car made to be operated in three double track sections on account of the skew at this point.

The railroad traffic was diverted to a temporary double-track span 200 ft. away and the removal of the old structure was commenced by stripping the rails and ties from its floors and cutting out the rivets in the connections of the intermediate floor beams and stringers, which were taken out by a derrick car and loaded on flat cars alongside. The end floor beams and the turn-table bracing were left in position to stiffen the girders and as soon as everything was clear the bridge was swung partly open and one end of one of the outside girders cut off through one of the shop riveted splices, lifted out by the derrick car and removed in the same manner as the smaller pieces. The bridge was then swung through a small arc, bringing the middle girder into position to have the ends cut off and removed, and so for the third girder after which the other end of the bridge was swung around 180 deg. and the same operations performed with it. The process was repeated at both ends of the bridge, cutting the girders down to the part over the turn-table when falsework trestles were built to it, permitting the derrick car and the service cars to approach it and finally remove the center portions of the girder and the turn-table in the same manner. The estimated weight of the center girder was about 1,000 lb. per linear foot, and it was at first proposed to lift it and the side girders bodily from the pier and carry them ashore in single pieces by means of a lighter at one end and the derrick car at the other. This plan was abandoned because the channel is so narrow that it would have been difficult to manœuvre the lighter in it. The old bridge was removed in three weeks by a force of about 25 men, in the employ of the Terry & Tench Co., of New York City.

The steel derrick car with which this work was handled is of special construction, designed by Mr. Edward F. Terry, assisted by Mr. John W. King, designer of special car equipments. It weighs complete 122,000 lb., and was built by the Terry & Tench Co. at their shops at 131st St. and Harlem River. It is 10 ft. wide, 51 ft. long, and is mounted on two four-wheel heavy trucks arranged with bearings wedged against the car body. The car has a King steel under-frame with a heavy continuous horizontal longitudinal member connected with the draft gear at each end and built with a T-shaped cross-section made up of two I-beam sections, one with a horizontal continuous web, and the other with a vertical web reaching from transom to transom and rigidly connected to each. This arrangement permits both transoms and draft gears to be continuous and provides for the support of intermediate transverse beams on the latter.

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The car has a floor of heavy wooden planks cle
and is stiffened with two vertical longitudin gles
side trusses 30 ft. long and 8 ft. deep, wh d col-
are located in the walls of the engine house ft. high
take the stress of the back stays from th
of the A-frame. The 20x9½-ft. engine sion forms
ft. high is covered with galvanized iron hipped from
galvanized iron corrugated sides di eted together
three panels hinged horizontally so bottom chords
per leaf opens upward to form a form cross sec-
projecting floor and side-wall of a pair of curved

formed by lowering the two other sections of the side-wall. This arrangement allows the engine house to be entirely opened in hot weather and at the same time provides additional space and a passageway around the machinery which, although outside the car proper is still within the clearance limit for a car on an adjacent double track.

The front transom has horizontal hinges pivoted to a transverse A-frame 16½ ft. high, made with two inclined members each having a T-shape cross-section made with a 12-in. I-beam and a 15-in. channel connected by a riveted arch portal near the base and at the top by a rigid heavy gusset plate bored for a 4x10-in. head iron with forged eyes for connecting links fore and aft.

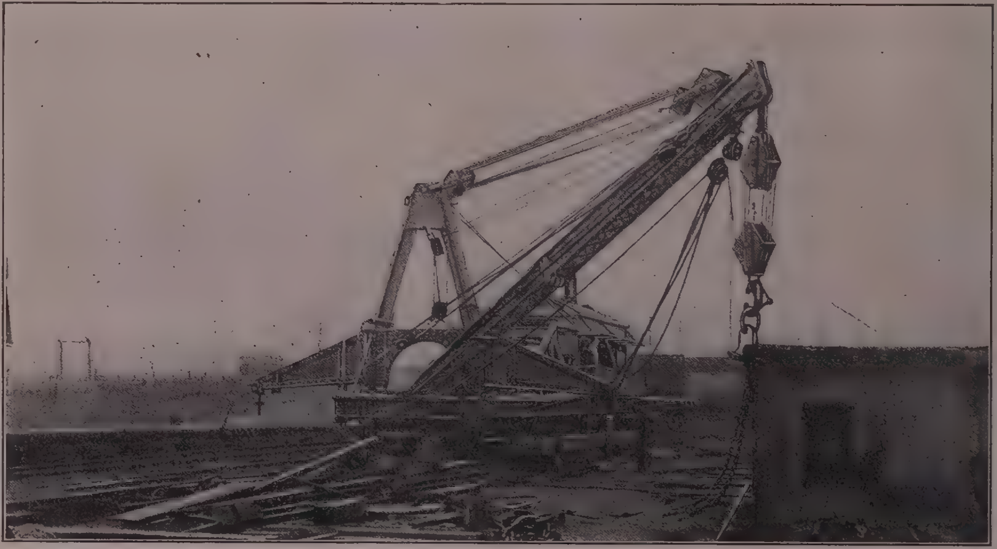
On each side of the A-frame there is at the base a 3-in. vertical pin about 4 ft. long, serving as a hinge for a plate girder outrigger about 10 ft. long. Each outrigger is fitted with three sets of vertical web stiffeners and bearings on the lower flange to which there are hinged special 4-in. jack screws 36 in. long reacting against blocking on the ground to insure lateral stability when the derrick car is in service. Usually, of course, only one jack screw is engaged under each outrigger at one time. The extremity of the outrigger is pin-connected to a horizontal strut reaching to the center of the car frame.

From the top of the A-frame two 1¼-in. turnbuckle back-stay rods are run to connections with the longitudinal trusses.

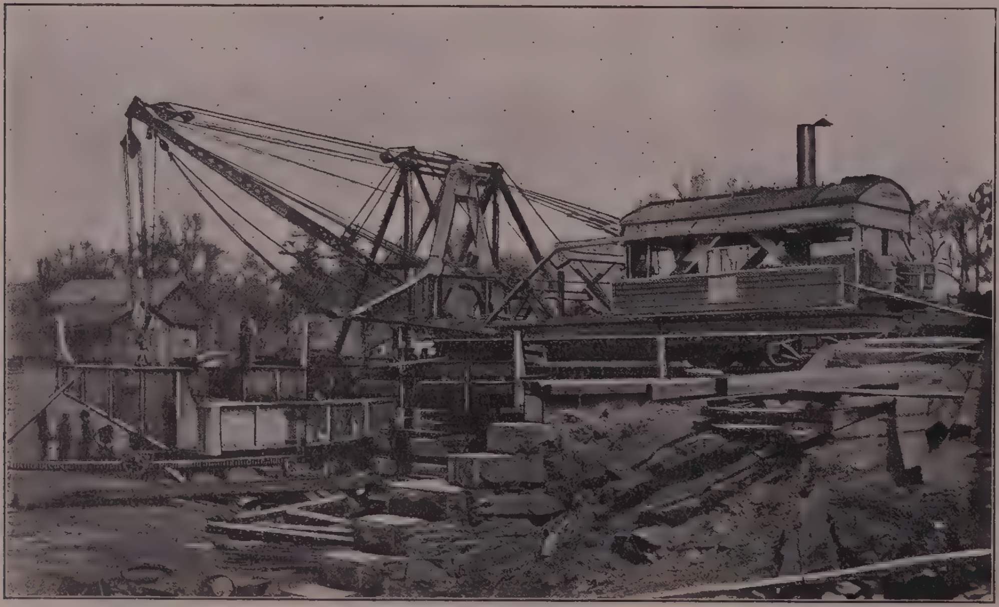
The boom has a rectangular cross-section made with 4x4x½-in. angles latticed on all sides, and is built in three 20-ft. sections connected with bolted splice plates. The two end sections are tapered and must always be used, but the center section is removable and may be used or not at pleasure. The lower section is pivoted to the forward transom with a 7-in. vertical pin and is generally connected directly to the outer section with the 20x24-in. center section omitted and only inserted for extra service. The two end sections are connected together by a hinge joint locked by the extended end of the bolted splice plate.

The A-frame can pass through ordinary bridges d clear the overhead bracing without being mantled. The only precaution being to lower point of the boom below the top of the A- If, however, the clearance is less than if it is desired to ship the derrick car istance in a train, the outriggers are ard, parallel with the axis of the car, m their extremities are led to the capstan heads of the hoisting engine and revolve the A-frame backward to an inclined position supported on seats on the longitudinal trusses at both sides of the car. The boom is then folded back on its middle hinge and revolved to rest on independent seats just above those of the A-frame. This reduces the vertical clearance to 14 ft. 4½-in. above the top of the rail.

The boom is rigged with an 18-part topping lift tackle and a 10-part hoisting tackle, both of them rove with ⅝-in. steel cable and provided with 20-in. sheaves. Two 1½-in. 4-part manila tackles are attached to the point of the boom and the extremities of the outriggers with their fall lines run to the capstan heads of the hoisting engines in order to swing the boom laterally. The 60-ft. boom has a capacity of 25 tons, 25 ft. from the center of the track.



Front View of Derrick Car, Showing Outriggers.



Removing Old Bridge.

The car is equipped with a 9¼x10-in. double-drum, four-spool Lidgerwood hoisting engine and boiler and an independent 8x8-in. double cylinder reversing horizontal engine made by the Chase Machine Works, Cleveland, Ohio, is direct geared to the rear axle of the forward truck and drives the car at a speed of 10 miles per hour. There is also a double duplex 5x7-in. air compressor made by the New York Air Brake Co., which has a capacity of 31 cu. ft. per minute at 110 lb. pressure and delivers to two 18x108-in. receivers, thus providing for the operation of four pneumatic hammers, and completely equipping the car for bridge erection work. The car can be operated by one man in addition to those required to attend the hoisting tackles and lines, and can be dismantled or put in service in less than 10 min. When in service it is anchored to the tracks by four rail clamps with turnbuckle adjustments. It is built within the M. C. B. clearance lines and in accordance with all M. C. B. requirements, so that it is acceptable in transportation in any train. It has Gould steel couplers and journal boxes, Ajax metal bearing and New York air brakes.

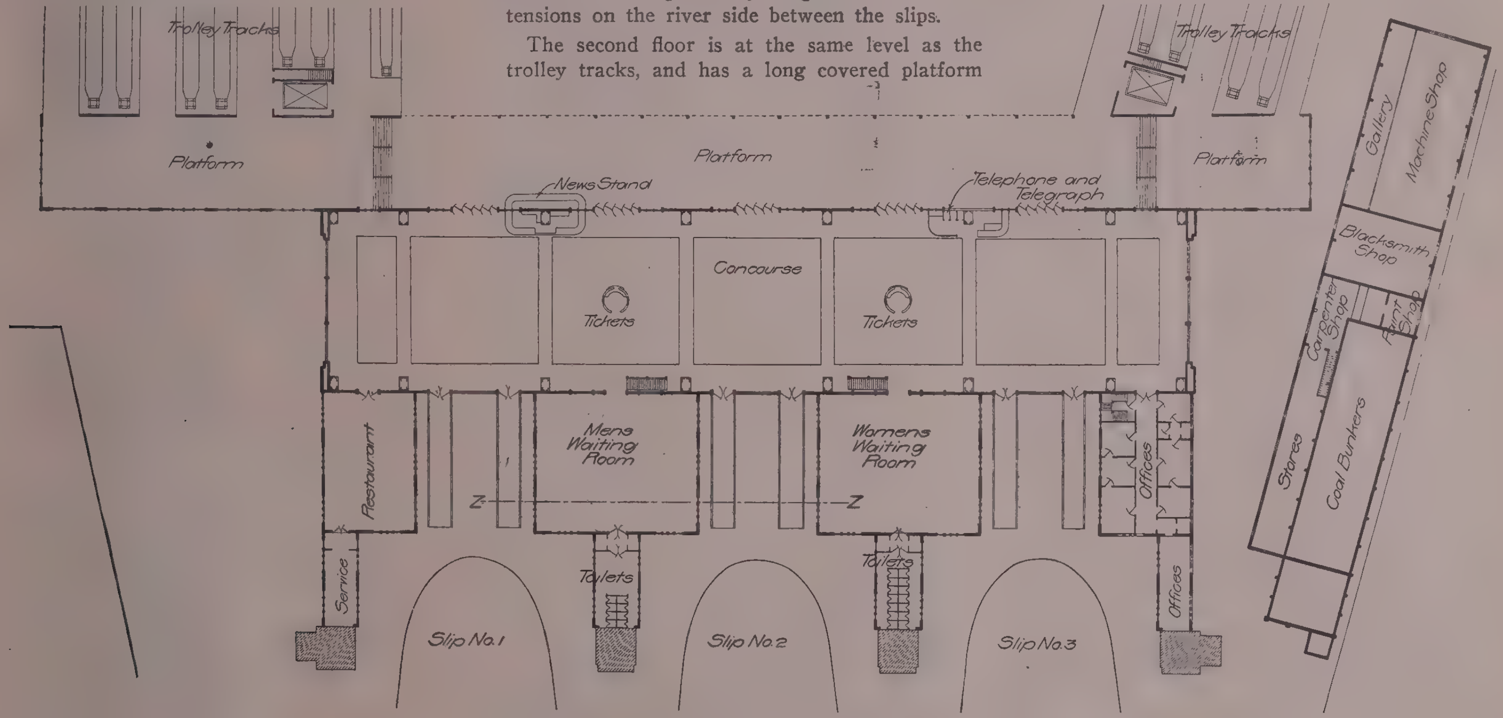
Westminster Cathedral, London.

Westminster Cathedral, London, one of the largest churches built in England in recent years, measures 156 by 361 ft. over all. The clear interior width of the nave is 60 ft., and the length 193 ft. The main counterforts are surmounted by segmental transverse arch ribs, between which are three segmental vaults forming the roof of the building, and rising to a maximum height of 111 ft. from the floor. The segmental vaults, which are 60 ft. in span at the base and have a rise of 20 ft. 8 in., are of concrete without reinforcing, 3 ft. thick at the springing line and 13 in. at the crown. They were cast in place on closely boarded centering in annular rings having a width of about 4 ft. each. Because of the height of the building the construction of the centering was very important. It was carried on radiating trusses which in turn rested on posts carried up 90 ft. from the floor, and heavily cross-braced to give rigidity under the heavy weight of the vaults. Over this concrete roof is an external covering of "artificial stone" concrete 3 in. thick, separated from the main shell by a 2-in. air space, and carried on radiating concrete ribs. There are three vaults of this size, a fourth vault over the sanctuary being somewhat smaller, though built in the same manner as the others. The preliminary sketches were made by Mr. John F. Bentley, about 12 years ago, and the structure was completed about 8 years afterwards, though the decoration of the interior will not be finished for many years.

An Erroneous Headline to the first letter in this journal on June 15 reads, "chloride of lime as an anti-freezing compound," although the communication referred to chloride of calcium. The error is not likely to cause any misapprehension, as all readers are doubtless aware that chloride of lime, used primarily in bleaching cotton, linen and paper, is altogether different from the chloride of calcium used as an anti-freezing compound.

The Staten Island Ferry Terminal.

The new terminal at St. George, Staten Island, has been designed and built by the Department of Docks and Ferries of New York City to provide terminal facilities for the municiapl ferry between Battery Park, Borough of Manhattan, and St. George, Borough of Richmond. It also acts as a union station for all electric street car lines on Staten Island, which converge at this point and for the three steam branches of the Staten Island Rapid Transit R. R., which radiate north, south and west from this point. It has three slips for the landing of the large, new, double-deck municipal ferry boats and will accommodate the very heavy summer traffic of day excursionists from New York to the beaches and numerous summer resorts on the island. It replaces a large steel ferry house built on the same site only a few years ago, and is an important element in the extensive scheme of water front improvements planned for Staten Island.



Plan of Upper Floor of Staten Island Ferry Terminal.

It has two main floors, the lower one about 10½ ft. above mean low tide, receiving some pedestrians and all of the teams and other vehicles which are carried on the lower decks of the boats, and an upper floor at about the level of the upper decks and of the electric car tracks. The steam car platforms are about midway between the upper and lower floors and passengers from them may enter the terminal at either level. The terminal makes abundant provisions for the present traffic with boats at 15 min. intervals during rush hours, and has a large margin for the great future increase which is anticipated. During the excursion season the boats carry as many as 3,000 passengers each, who on the incoming trip usually pass directly through the terminal to the steam and electric cars, but on the outgoing trip they gather continually from these lines and wait some time at the terminal for the boats.

The terminal is adjacent to the frieght yards of the Baltimore & Ohio R. R., and is supported entirely on a pile sub-structure beyond which the surface of the ground is graded to the yard level a few feet above high tide for a distance of about 300 ft., where it abruptly rises about 20 ft. to street level. The intervening space across the yard is covered by a massive wooden viaduct and a double-track steel truss bridge across the main tracks.

The terminal superstructure has a steel framework and consists of two principal buildings, the 128x332-ft. terminal proper, and the 38x232-ft. coal and shop buildings. The two-story terminal is extended on the shore side by a 56x480-ft. two-story steel wing with trolley platform and canopy on the upper floor. The terminal building is about 80 ft. high from deck to top of roof and has in each story a full length hall 58 ft. wide, which forms an unobstructed concourse in the upper story. The roof over the hall is much higher than that at the sides and is independently carried by a series of steel arch trusses forming in the upper story a long vista of impressive height and distance.

The lower floor has a wide central driveway on the spring platform which receives the impact from the buffers at the shore end of the suspended bridges in the three slips. On one side of the driveway are the cab stands, express office, post office, and power plant. On the opposite side is a restaurant, waiting-room, employees' room and offices with comparatively long and narrow extensions on the river side between the slips.

The second floor is at the same level as the trolley tracks, and has a long covered platform connected with two divergent canopies, not shown on the accompanying plan, adjacent to different groups of tracks and communicating to several wide groups of doors with the 50x325-ft. concourse hall about 48 ft. high to the center of the roof truss. There are two 64 x 52-ft. waiting rooms, a restaurant and a set of offices. Between the waiting rooms and on each side of them there are three transverse extensions covering the inner ends of the slips and affording sheltering for the ferry boats landing or receiving passengers.

The lower story has a wooden deck with double crossed wooden floors in the restaurant and waiting rooms. The remainder of the deck is covered with 1⅛-in. matched and dressed Georgia pine. The reinforced concrete upper floor has a brick and granolithic wearing surface in the concourse and has a double wooden surface in the waiting rooms and restaurants. The pitched concourse roof is made with three thickness of matched North Carolina pine ⅞ in. thick, separated 1 in. by furring strips 2 in. wide and carried on 3 x 6-in. yellow pine rafters 20 in. apart.

The most interesting part of the structural steel is that in the concourse frame-work which has six main transverse vertical double bents. These are located in three intermediate 54-ft. panels and two 26-ft. 9½-in. end panels. Each double bent has a pair of trusses 26¾ in. apart on centers which are connected together by shop riveted ties and lattice bars to form a main rib. They have arch trusses of 58-ft. clear span and 28-ft. 10-in. clear rise with top and bottom flange angles, the latter tangent and continuous at the ends with the inner flanges of the vertical posts 35 ft. 8 in. long which are thus made integral with the trusses and unite the wall and roof framing.

The arch trusses carry on their top flanges seven longitudinal lines of lattice girder purlins of different depth proportioned to the distance at alternate panel points where they are seated, between the top flanges of the roof trusses and the inclined roof plane. The top flanges of the purlins are made with pairs of channels back to back, the bottom flanges and all of the web members are each made with a pair of angles back to back.

In general, the purlins are made with 6 panels about 9 ft. long and the ends of adjacent purlins are connected across the arch ribs with short X-braced panels across which the top flanges are spliced, thus making continuous longitudinal beams to carry the single 6-in. 12-lb. I-beam jack rafters 8½ ft. long, web-connected to the top flanges of the purlins at their panel points. Where the distance between the arch truss and roof is moderate, the bottom flanges of the purlins are seated directly on the top flanges of the roof trusses; where the distance is too great for this construction, the vertical end posts of the purlins are continued below the lower flange to form pedestals carrying the purlins at the required heights above the arch trusses.

The outside panels between purlins and jack rafters on all four sides of the roof are X-braced with single 3 x 3 x ⅜-in. angles, with their vertical flanges turned in opposite directions and their horizontal flanges riveted together at intersections. There is no lateral bracing in the plane of the roof except this marginal X-bracing, but the trusses are stiffened by the double thickness of sheathing boards already mentioned whi are nailed on 3 x 6-in. wooden rafters 20 apart on centers intermediate between th jack rafters.

The concourse floor, proportioned fo load of 100 lb. per sq. ft., is carried verse girders from about 16 to 19 ft

34 in. deep. Their heaviest flanges are made with pairs of 6 x 4 ¾-in. angles reinforced by one full-length and one part-length 14 x ¾-in. cover plates. Girders 45 ft. long over all, are, at panel points, supported at one end directly by the main arch truss posts and at the opposite end are carried on small one-story steel columns from the main deck.

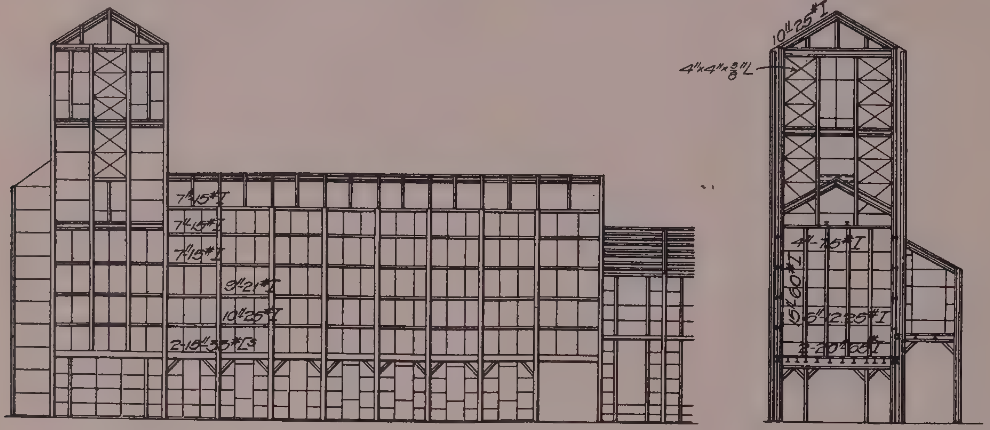
The two intermediate girders in each regular main panel are carried in the same manner at one end and are web-connected at the opposite end to a longitudinal girder of substantially the same cross section with its web field riveted across the inner faces of the arch truss posts. The lower course transverse floor planks are covered on the top flanges of 9-in. and 10-in. longitudinal I-beams in the intermediate panels nd 15-in. I-beams in the end panels which are aced about 8½ ft. apart and are web-connected the transverse girders. On the west side of building the floor in the space between the f the transverse girders and the wall is on 10-in. transverse I-beams about 18 ft. 5 ft. apart, web-connected to 15 and 20-linal I-beams.

r over the trolley platform at con-course floor level is formed by the upper part of a 2-story steel shed 34½ ft. wide and 42 ft. high above the deck. The wall columns are connected transversely by double-pitched transverse roof trusses 8 ft. deep at the center where they support a line of light lattice girder purlins of the same depth. The ends of the trusses are knee-braced to longitudinal struts with closed rectangular cross-sections connecting the wall columns just below their upper ends. The upper floor is carried by 10-in. transverse I-beams about 9 ft. apart, supported by the wall columns and intermediately by a 1-story center post.

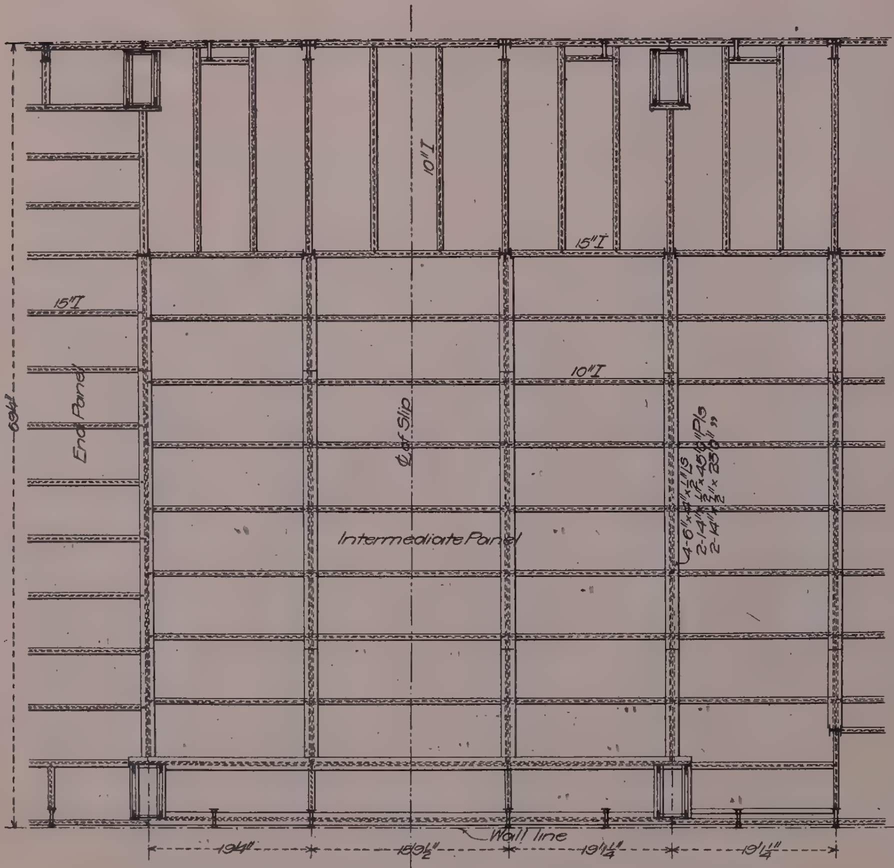
The gable walls have a frame-work of vertical and horizontal steel struts dividing the surface into rectangular panels of a maximum width of 8 ft. The wall is panelled by a center false arch parallel with the main roof arches, but of smaller dimensions, having a clear span of about 46 ft. rise of 23 ft., and total height of about 58 ft. above the deck. The upper part of the archway is closed by framing like that outside of it in the remainder of the wall, which is carried on a 30-in. plate girder at concourse floor level, providing underneath a clear opening 14 ft. high above the main deck and of the width of the arch.

On the east side the building is extended beyond the concourse wall by a series of transverse 2-story structures over and between the slips which have a continuous roof made with a succession of gables and intermediate portions as indicated in the longitudinal elevation diagram parallel to the axis of the concourse. The lattice girder roof trusses over the ferry slips are proportioned for a live and dead load of 75 lb. per sq. ft. of roof surface besides the weight of the suspended foot bridges from the concourse floor to the upper decks of the ferry boats. Their lower flanges are curved to give them an arch-like appearance, and their top flanges are extended one panel beyond the end of truss proper to form rafters for the part of the roofs of the intermediate structures betwen the slips for the waiting rooms, restaurants, offices, etc., previously mentioned.

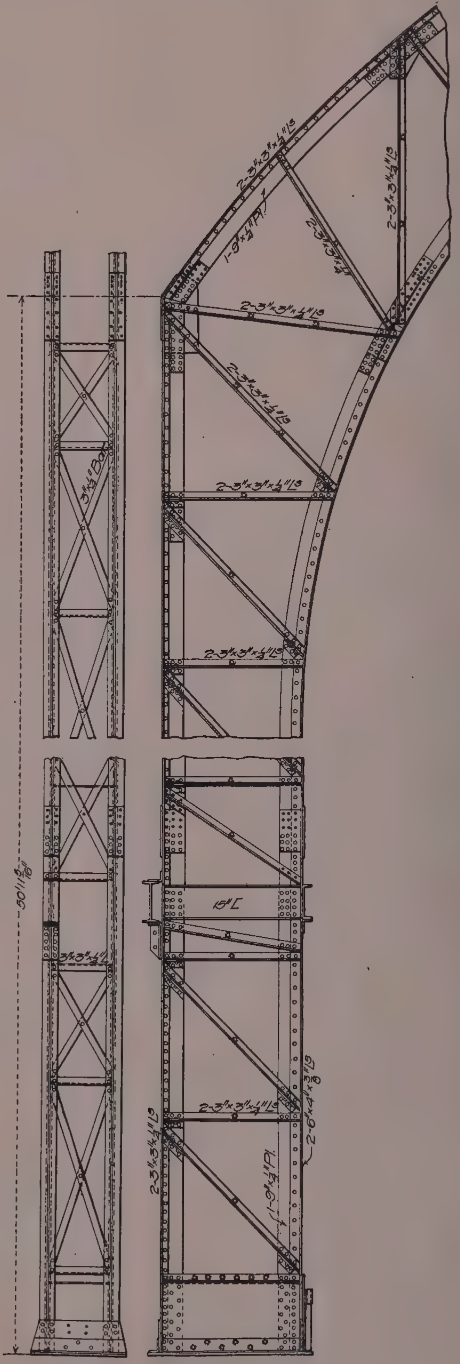
The roofs over the ferry slips are about 100 ft. long in a direction transverse to the axis of the concourse and at the outer end the lattice girder trusses are replaced by pairs of 3-hinge plate girder arches of 90 span 9½ ft. apart with the space between them filled with an ornamental paneled soffit between their lower flanges.



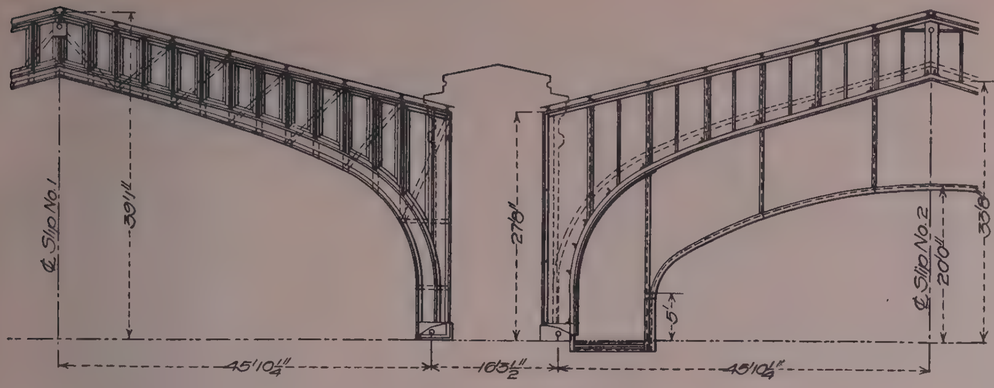
Coal Bunker.



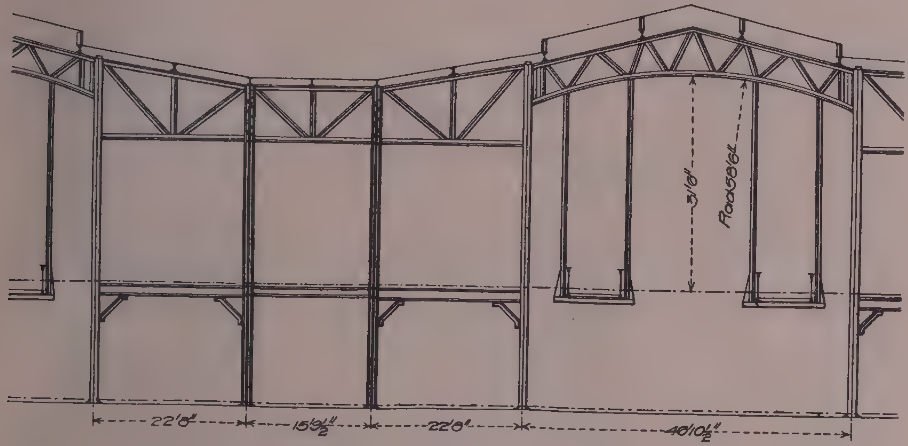
Part Plan of Concourse Floor.



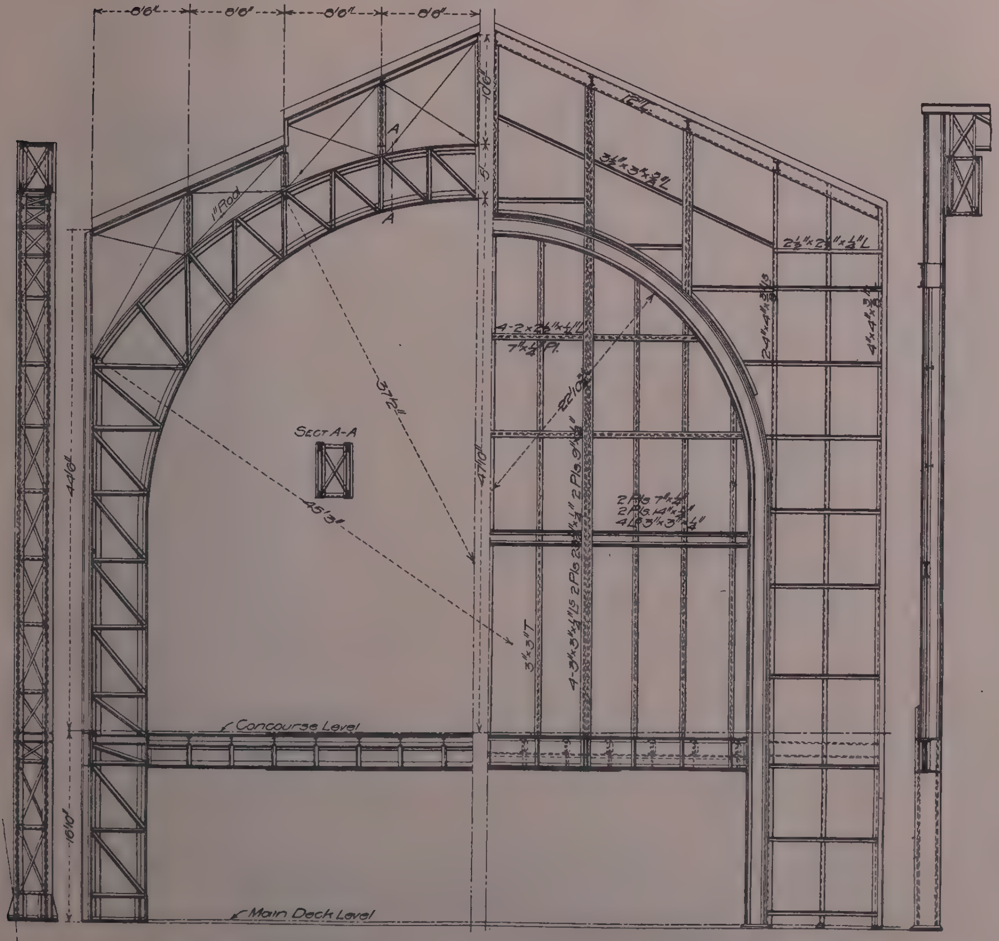
End of Concourse Truss.



Arch Spans over Slips.



Section Z-Z. Part Elevation of Front.



Half Cross Section. Half End View.

The coal bunker 140 ft. long and 24 ft. wide has at one end a 24 x 24-ft. elevator tower about 90 ft. wide and has a capacity for 1,500 tons of coal. It is of very simple construction with a rectangular bin 24 ft. wide and 26 ft. high with a floor 14 ft. above the level of the deck and a main roof 56 ft. above the level of the dock. The horizontal reinforced concrete floor is proportioned for a load of 1,400 lb. per square ft. and is carried on knee-braced longitudinal I-beams. The vertical walls of the coal pockets are made with 6-in. thick slabs of reinforced concrete cast between the webs of the main columns and of intermediate vertical posts 4 ft. apart.

The wall columns 12 ft. apart have I-shaped cross sections made with a 24 x ⅜-in. web and 4 x 4 x 5/16-in. flange angles. They are connected at the level of the bin floors by longitudinal girders made with a pair of 15-in. 33-lb. channels, one 12 x ⅜-in. cover plate, and two 4 x 4 x ⅜-in. flange angles. Above these girders each side wall is stiffened by four lines of longitudinal horizontal struts about 6 ft. apart, made with single horizontal I-beams 10 in., 9 in., 7 in. and 7 inches deep respectively, from the bottom up. These struts brace the intermediate vertical struts which in the two lower panels are made with 6-in. and in the three upper panels with 5-in. and 4-in. I-beams. The upper longitudinal edges of the bin are tied together with horizontal transverse I-beams and channels at panel points and the roof is made with 7-in. I-beam rafters and a 10-in. ridge beam.

The 1:3:5 cinder concrete roof slabs 7 in. thick are flush on the top and bottom surfaces with the flanges of the I-beams and are covered on top with ⅞ x 8-in. matched and dressed North Carolina pine siding nailed to 2 x 2-in. furring strips 20 in. apart and covered with tin. The bottom of the coal bunker is provided with chutes through which coal is delivered to carts on the dock floors and pushed by hand to the ferry-boats. The space under the bunker is enclosed by side-walls built on a frame-work of 6-in. intermediate vertical channels 4 ft. apart and 6-in. horizontal channels 3 ft. apart in the planes of the main columns to which they are connected. They are sheathed with ⅞-in. siding covered with No. 20 galvanized corrugated iron.

The machine shop and blacksmith shop form a 40 x 100-ft. extension to the coal bunker building and have a steel frame-work made with two-column transverse bents 12 ft. apart and about 43 ft. high. The roof is made with 12-in. I-beam rafters and nine lines of 7-in. 15-lb. I-beam purlins and the side-walls have light I-beam and channel frames for the 6 x 14-ft. windows in each regular panel. The walls are made with an outside sheeting of 8 x ⅞-in. dressed North Carolina pine covered with No. 20 galvanized corrugated iron and the inner surface is covered with No. 24 galvanized corrugated iron on horizontal furring strips nailed 16 in. apart with a 2 x 4-in. spruce studding. The walls of the upper and lower stories of the concourse and of the cab stands have vertical 2 x 6-in. spruce studs about 3 ft. apart sheathed on both sides with 8 x ⅞-in. dressed North Carolina pine covered with galvanized corrugated iron of No. 20 gauge outside and No. 24 gauge inside.

The hingeless arch trusses in the concourse roof have three centered segmental curves for their top chords and have radial depths of 5 ft. and 8 ft. over all at the crown and haunches respectively. The radius of the lower flange at the bottom chord is 29 ft. at the crown and that of the top flange of the top chord is 37 ft. 4 in. at the crown and 45 ft. 5 in. at the springing line, where the curve intersects the vertical exterior face of the columns integral with the truss. Th
bottom chord is bent to a complete semi-cir
tangent at the ends with the vertical a
forming the interior faces of the connecte
umns, 5 ft. wide over all, and about 51
on the outer face.

Each truss with its two-column exten
a single continuous transverse bent s
the bridge shop in six sections field ri
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of the arch truss each have uni
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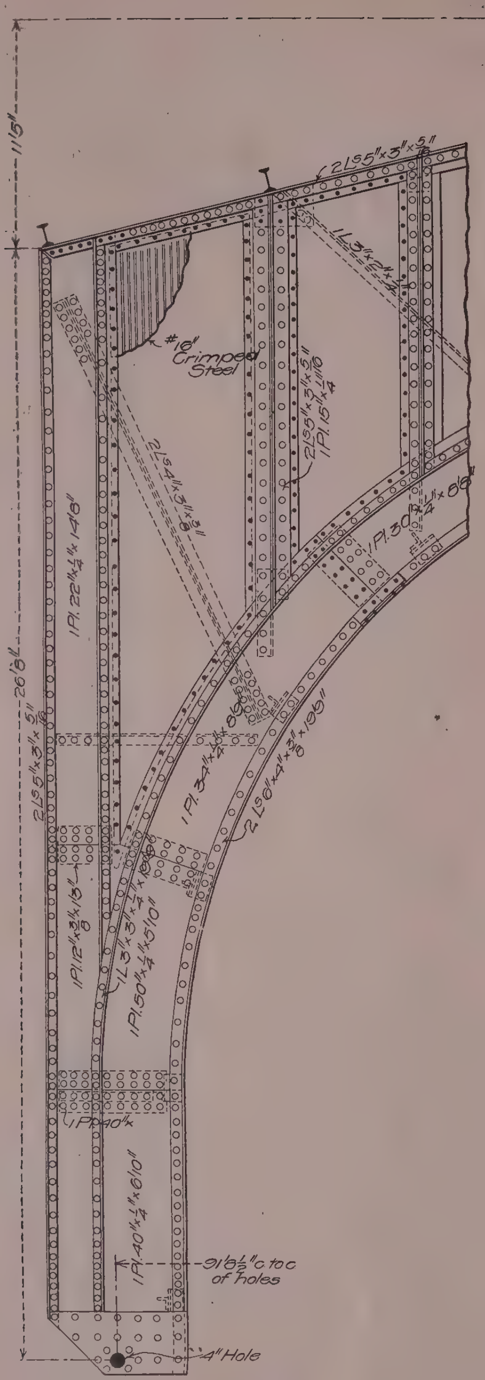
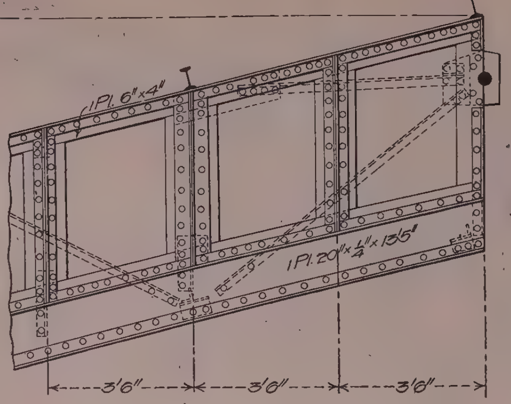
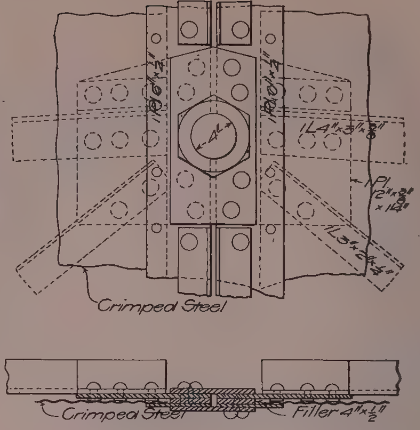




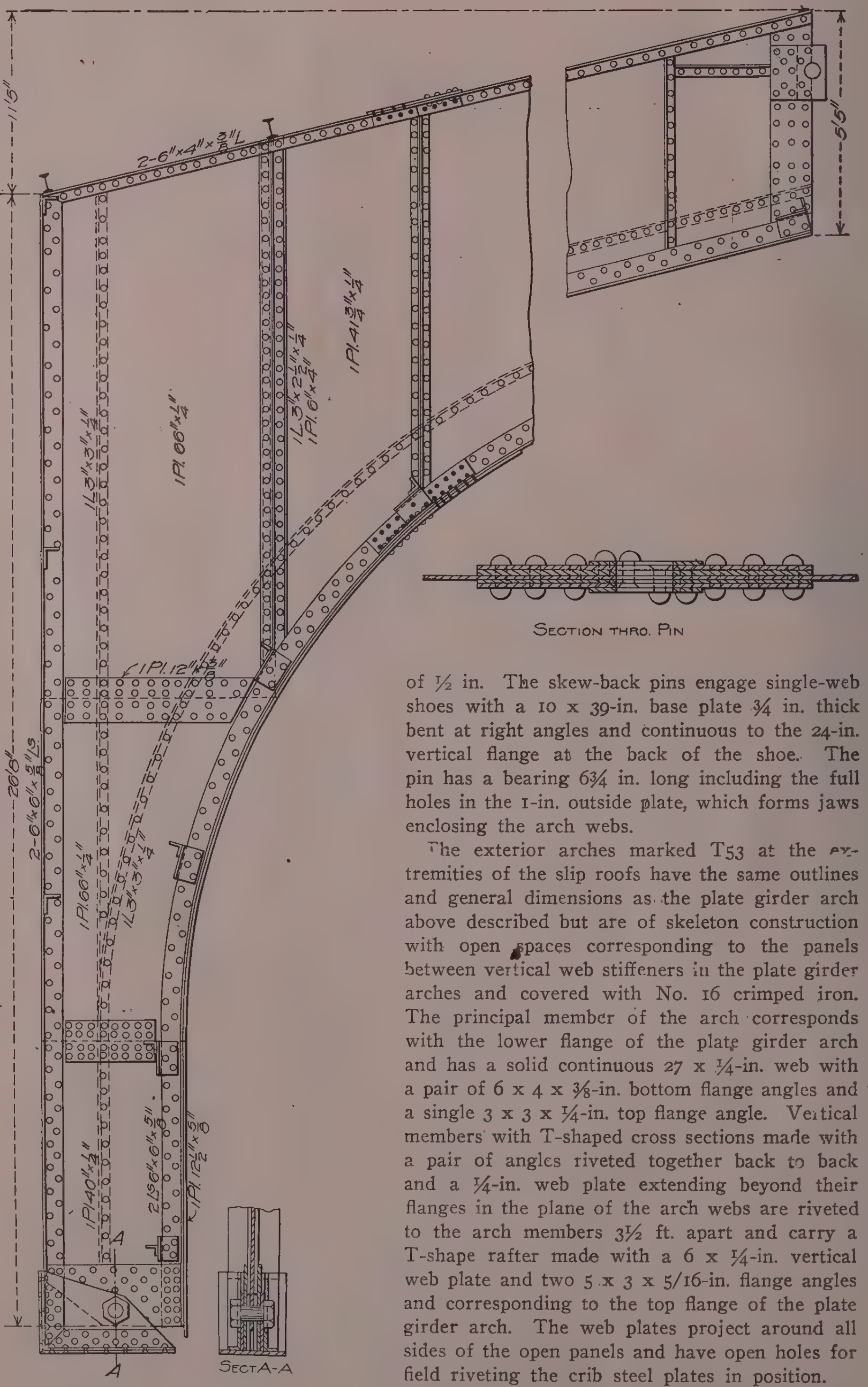


Crown Hinge, Three-Hinge Arch.

Three-Hinge Arch over Slip.

flange angles of the full length of the section and two panel lengths of 9 x ¼-in. vertical web plates. The top chord has 3 x 3 x ¼-in. flange angles and the bottom chord has 6 x 4 ⅜-in. flange angles. The chords are continuous through the vertical osts where they form the flanges and have the same cross section. All vertical and diagonal web members in the truss and columns are made with pairs of 3 x 3 x ¼-in. angles back to back. The twin halves of each truss are connected by 3 x 3-in. horizontal transverse angles and 3 x ¼-in. lattice bars. The columns have 40 x 68-in. base plates and are bolted to the timber deck.

The 3-hinge plate girder arches at the end the ferry slip roof have a span and rise of . 8½ in. and 36 ft. 7 in. respectively on hinge s. The depth over all is 5 ft. 5 in. at the 26 ft. 8 in. at the haunches. The web has m thickness of ¼ in. and is stiffened 2½-in. vertical angles 3½ ft. apart. nges are made with a pair of 6 x 4 x and the bottom flange with a pair ¼-in. angles. Each semi-arch was pieces field spliced with web and es. The skew-back and crown hinge pins are 4 in. in diameter and the crown pin has full-hole bearings locking the jaw plates in position. The vertical joints between the webs of the semi-arches at the crown has a clearance of ½ in. The skew-back pins engage single-web shoes with a 10 x 39-in. base plate ¾ in. thick bent at right angles and continuous to the 24-in. vertical flange at the back of the shoe. The pin has a bearing 6¾ in. long including the full holes in the 1-in. outside plate, which forms jaws enclosing the arch webs.



Section thro. Pin

Plate Girder Arch over Slip.

The exterior arches marked T53 at the extremities of the slip roofs have the same outlines and general dimensions as the plate girder arch above described but are of skeleton construction with open spaces corresponding to the panels between vertical web stiffeners in the plate girder arches and covered with No. 16 crimped iron. The principal member of the arch corresponds with the lower flange of the plate girder arch and has a solid continuous 27 x ¼-in. web with a pair of 6 x 4 x ⅜-in. bottom flange angles and a single 3 x 3 x ¼-in. top flange angle. Vertical members with T-shaped cross sections made with a pair of angles riveted together back to back and a ¼-in. web plate extending beyond their flanges in the plane of the arch webs are riveted to the arch members 3½ ft. apart and carry a T-shape rafter made with a 6 x ¼-in. vertical web plate and two 5 x 3 x 5/16-in. flange angles and corresponding to the top flange of the plate girder arch. The web plates project around all sides of the open panels and have open holes for field riveting the crib steel plates in position.

The docks, platforms, slips and all of the substructure were designed and constructed under the direction of the Department of Docks and Ferries, Mr. John A. Bensel, commissioner, Mr. Charles W. Staniford, chief engineer, and Mr. S. W. Hoag, Jr., assistant engineer. The superstructure was designed and supervised by Carrere & Hastings, architects, and Mr. Owen Brainard, consulting engineer. The substructure contract was executed by George B. Spearin. The building contract, which is practically completed, was executed by The Snare & Triest Co. The steel frame for the super-structure weighs about 1,725 tons and was fabricated partly by the Snare & Triest Co. at their Jersey City shops, and partly by The Hay Foundry & Iron Works, Newark.

Reinforced Concrete Caissons for Bridge Piers.

Two piers for the Strabane and Letterkenny Ry., across the River Foyle, England, have had their foundations carried to a depth of about 20 ft. below the surface of the water by means of reinforced concrete caissons or open cofferdams. They are 31 ft. 3 in. long and 8 ft. wide over all, with parallel vertical sides and both ends pointed at an angle of 45°. The exterior walls have a uniform thickness of 6 in., and are joined by four vertical transverse interior walls or diaphragms of the same thickness. The outer walls are reinforced near the inner surface with ⅝-in. round vertical rods, 15 in. apart and with ⅝-in. horizontal rods 6 in. apart.

The caisson was made with vertical sections or courses 2 ft. high, each of them forming a monolithic piece of the full cross-section of the pier. They weighed 7 or 8 tons each, were molded on shore, and when four weeks old were lifted by a derrick with chains attached to them at six points and lowered to position in the river. Six 2x½-in. full-length vertical bars were attached equidistantly to the lower section or cutting edge and extended above the surface of the water, forming guides which entered corresponding holes left for them in the succeeding upper courses and guided the latter to proper bearings on the lower courses. The joints between the courses were made with V-shaped tongues and grooves, having rolls of cement mortar encased in muslin laid in the groove to receive the tongue. The caissons are illustrated in a recent issue of "Engineering," of London, which states that their cost was about one-half that estimated for metal caissons. The article does not describe the method of sinking, but as it states that the caissons were quite water-tight, it is to be inferred that they were pumped out and sunk by open interior excavation. Mr. James Barton was the engineer and Robt. McAlpine & Sons were the contractors.

The Training for Draftsmen in the school of the General Electric Co. at Schenectady begins with a stiff examination in arithmetic, which most candidates fail to pass. Those admitted first spend about three months in the blue-print department. They are then transferred to the tracing department, where they are kept for six months, this period being about sufficient to turn out an expert tracer. This work covers all told nine months, which makes up the first school year. The second year the student is kept in the factory, being transferred as a rule every three months. He has to assemble switchboard apparatus, switches, searchlights, motors, work in the shop, make tests and do other work which will familiarize him with the methods followed in the different departments of the company's works. The two final years are spent in the drafting room. During all this time the student is requested to study algebra, geometry, trigonometry, projections, the use of the slide rule, the stresses and strains of materials and to draw and trace fifty sheets from sketches furnished to him. The pay ranges from $3.40 a week during the first six months to $7.50 a week during the last year.

A Judicial Review of American Stream Pollution Decisions.

An illuminating review of the opinions expressed by American courts in cases concerning the pollution of streams by sewage was recently written by Judge Hainer, of the Oklahoma Supreme Court in deciding the case of Markwardt v. City of Guthrie, 90 Pac. Rep. 26. The city, which has about 25,000 population, is traversed by Cottonwood Creek, into which its sewage was turned in 1902. Prior to that date the plaintiff had developed a 10-acre truck farm by means of water taken from the stream about 1½ miles below the city. After the sewerage system was put in operation the water became unfit for the uses to which it was put on the farm and the owner accordingly brought suit for damages. This suit was eventually carried to the Supreme Court, which considered it with particular care on account of the importance of the decision as a precedent for such cases in Oklahoma. The laws of the territory, it is pointed out, permit Guthrie to construct and maintain a sewerage system only within its limits, and there is no express power to extend the system beyond its boundaries nor to use natural drainage courses as receptacles for sewage, a privilege granted by the laws of some States. Consequently the basis of the action was that the city wrongfully maintained a sewer which was a public nuisance and detrimental to the health and business of the plaintiff.

The great weight of the American and English authorities, according to Judge Hainer, hold that a municipal corporation is liable for the wrongful maintenance of a public nuisance under such circumstances. In Edmondson v. City of Moberly, 11 S. W. 990, the Supreme Court of Missouri had this same question under consideration. It appears that the city of Moberly was authorized by its charter to build and maintain a system of sewers for the drainage of its streets, and for the maintenance of the public health. In 1885, under an ordinance to that effect, it constructed a number of sewers for the drainage of the city. These drains, when completed, discharged the sewage finally into a small running stream near plaintiffs' residence, within the city limits. Plaintiffs' evidence tended to show that this discharge was so filthy and noxious that it polluted the stream, produced a sickening stench upon plaintiffs' premises, impaired their enjoyment of their home, diminished its value, and caused sickness in their family. At the conclusion of the plaintiffs' evidence the court declared the law to be that the plaintiffs could not recover. From this ruling and judgment the plaintiffs appealed. Justice Barclay, in delivering the opinion of the court, said: "Conceding full effect of the authority conferred by the city's charter to establish a sewer system, it yet falls far short of legalizing the municipal acts here in question. The power granted was general. It did not expressly indicate and sanction the particular arrangement of drains adopted. Hence the power itself must be regarded as subject to the just limitation forbidding its exercise in such manner as to create a nuisance injurious to private rights of property, where such a consequence is not a necessary result of exerting the power. This principle is now quite generally recognized as part of our American common law. Seifert v. Brooklyn (1886), 4 N. E. 321; Morse v. Worcester (1885), 2 N. E. 694; Railroad Co. v. Baptist Church (1882), 2 Sup. Ct. 719."

In Joplin Consolidated Min. Co. v. City of Joplin, 27 S. W. 408, Chief Justice Black, speaking for the Supreme Court of Missouri, says: "The proprietor of land through which a stream flows cannot insist that the water shall come to him in the natural, pure state. He must submit—and that, too, without compensation—to the reasonable use of it by the upper proprietors, and he must submit to the natural wash and drainage coming from towns and cities; but a city has no right to gather its sewage together, and cast it into a stream, so as to injure the lower proprietor. For damages thus sustained, the lower proprietor will have an action, and, in many instances, injunctive relief. Locks and Canals v. City of Lowell, 7 Gray, Mass., 223; Haskell v. City of New Bedford, 108 Mass. 208; Vale Mills v. Nashua, 63 N. H. 136; Chapman v. City of Rochester, 18 N. E. 88; Lewis, Em. Dom. Sec. 65."

The Supreme Court of California, in Peterson v. City of Santa Rosa, 51 Pac. 557, and People v. City of San Luis Obispo, 48 Pac. 723, holds that the pollution of water by the flow of sewage from towns and cities into streams, whereby the water is injured or rendered unfit for use, is an injury for which the city is liable, and goes even to the extent of holding that injunction will be granted to restrain the continuance thereof.

The Supreme Court of Pennsylvania has had this same question before it, in the case of Good v. City of Altoona, 29 Atl. 741, where it was said: "The plaintiff is the owner of a farm situated three miles from Altoona, through which a stream known as 'Mill Run' passes. The bed of the stream is limestone rock, through seams and fissures in which a part of the water finds a subterranean passage and feeds two springs near the farm buildings, from which water is procured for the stock and for domestic purposes. The city of Altoona constructed sewers, the contents of which flow into this stream, with the result to the plaintiff that the water of the stream and of the springs is so polluted as to be unfit for any use, and at times, when the water overflows the banks of the stream, deposits of filth are left on his fields. By digging wells he has been unable to obtain pure water, as on account of the crevices in the rock the whole underground supply is polluted, and he is unable to obtain water for use on his farm, except from a great distance and at great expense. The issignments of error raise two questions: First, whether there is any liability on the part of the defendant; and, second, whether the recovery, if any can be had, shall be for a permanent injury. These questions were both properly submitted at the trial, and the jury found that the act of the defendant destroyed or seriously impaired a property right which the plaintiff possessed in a stream, and that there was no practicable method by which this injury could in the future be averted, and that it was continuing and permanent."

In Chapman v. City of Rochester, 18 N. E. 88, the Court of Appeals of the State of New York has upheld this doctrine. The plaintiff, who resided in the suburbs of the city of Rochester, had collected the waters of a stream, which arose in the city and flowed across his premises, in an artificial basin, for domestic purposes, etc. The city constructed sewers which discharged not only surface water, but the sewage from houses, and the contents of a large number of water-closets, into the stream above the plaintiff's land, so as to render the water unfit for use, and covered the banks with filthy sediment. It was held that the plaintiff was entitled to damages for injuries to health and property and an injunction restraining the nuisance. Judge Danforth, speaking for the court, in the course of the opinion said:

"In view of the principle upon which these and like decisions turn, the objections of the learned counsel for the defendant, against the judgment appealed from, are quite unimportant. The filth of the city does not flow naturally to the lands of the plaintiff, as surface water finds its level, but is carried thither by artificial arrangements prepared by the city, and for which it is responsible. Nor is the plaintiff estopped by acquiescence in the proceedings of the city in devising and carrying out its system of sewerage. The principle invoked by the appellant has no application. It does not appear that the plaintiff in any way encouraged the adoption of that system, or that by any act or word he induced the city authorities to so direct the sewers that the flow from them should reach his premises. There is no finding to that effect, and the record contains no evidence. In fine, the case comes within the general rule which gives to a person injured by the pollution of air or water, to the use of which in its natural condition he is entitled, an action against the party, whether it be a natural person or a corporation who causes that pollution." This decision was approved by the Supreme Court of the United States in the case of Missouri v. Illinois & Chicago District, 180 U. S. 208, 21 Sup. Ct. 331, 45 L. Ed. 497.

One of the best considered cases, in the opinion of Judge Hainer, is that of Platt Brothers & Co. v. City of Waterbury, 45 Atl. 154, decided January 4, 1900. The entire subject is exhaustively treated, and the leading American and English cases reviewed. In the course of the opinion Judge Hamersley said: "The main contention of the defendant may be stated in this way: The use of the sewers under authority of the Legislature in the manner described is a public, governmental use. The injuries to the plaintiff result from this governmental use, and are not direct, but merely consequential. The victim of consequential injuries resulting from a governmental use is entitled to no remedy, unless one is given by statute. The defendant's charter provides no remedy for consequential injuries resulting from the use of said sewers. Ergo, the plaintiff has no remedy, and its damage is damnum absque injuria. The premises essential to this conclusion are untrue. A governmental use may include any act which the state may lawfully perform or authorize. There are, however, governmental acts to which certain immunities attach, and it is with this restricted meaning that the phrase is used by the defendant. In this sense a governmental act is one done in pursuance of some duty imposed by the state on a person, individual, or corporate, which duty is one pertaining to the administration of government, and is imposed as an absolute obligation on a person who receives no profit or advantage peculiar to himself for its execution."

Again, the judge says: "We think it evident that the mere granting of authority to a city to construct, for the convenience and benefit of its inhabitants, sewers adapted to carry off their refuse matter to some neighboring stream, does not necessarily make such use of the sewers a governmental use, in the sense indicated. On the other hand, it is also evident that the Legislature may impose the duty of constructing sewers in such manner as to make the performance of that duty a strictly governmental act; but if, for the purpose of this case, we concede the defendant's claim that the use is a governmental use, it is nevertheless liable to the plaintiff. The injury described by the complaint is not a mere consequential damage, like that resulting wholly from the lawful use of one's own property or the the lawful exercise of governmental powers. It is a direct appropriation of well-recognied property rights within the guaranty of the Constitution. 'The property of no person shall be taken for public use without just compensation therefor.' Nolan v. New Britain, 38 Atl. 707."

Again, in the same opinion, it is said: "The right to pour into the river surface drainage does not include the right to mix with that drainage noxious substances in such quantities that the river cannot dilute them, nor safely carry them off without injury to the property of others. The latter act is in effect an appropriation of the bed of the river as an open sewer, and the proposition that it may become lawful by reason of necessity is inconsistent with undoubted axioms of jurisprudence. The appropriation of the river to carry such substances to the property of another is an invasion of his right of property. When done for a private purpose, it is an unjustifiable wrong. When done for a public purpose, it may become justifiable, but only upon payment of compensation for the property thus taken. Public necessity may justify the taking, but cannot justify the taking without compensation. It may be necessary for a city to thus mix with its drainage such substances, but it is not necessary to pour such mixture into the river without purification. Indeed, the purification is coming to be recognized as a necessity. But, however great the necessity may be, it can have no effect on the right to compensation for property taken. The mandate of the Constitution is intended to express a universally accepted principle of justice, and should receive a construction in accordance with that principle, broad enough to enable the court to protect every person in the rights of property thus secured by fundamental law."

In Pumpelly v. Green Bay Co., 80 U. S. 177, 20 L. Ed. 557, a similar question was before the Supreme Court of the United States, where Mr. Justice Miller clearly and forcibly states the doctrine at follows: "The argument of the defendant is that there is no taking of the land, within the meaning of the constitutional provision, and that the damage is a consequential result of such use of a navigable stream as the government had a right to for the improvement of its navigation. It would be a very curious and unsatisfactory result, if, in construing a provision of constitutional law always understood to have been adopted for protection and security to the rights of the individual as against the government, and which has received the commendation of jurists, statesmen, and commentators as placing the just principles of the common law on that subject beyond the power of ordinary legislation to change or control them, it shall be held that, if the government refrains from the absolute conversion of real property to the uses of the public, it can destroy its value entirely, can inflict irreparable and permanent injury to any extent, can, in effect, subject it to total destruction without making any compensation, because, in the narrowest sense of that word, it is not taken for the public use. Such a construction would pervert the constitutional provisions into a restriction upon the rights of the citizen, as those rights stood at the common law, instead of the government, and make it an authority for invasion of private right under the pretext of the public good, which had no warrant in the laws or practices of our ancestors."

This question was also before the Supreme Court of the United States in the noted case of Missouri vs. Illinois & Chicago District, 21 Sup. Ct. 331, where it was said: "This suit was brought by the state of Missouri against the state of Illinois and the Sanitary District of Chicago. The latter is alleged to be 'a public corporation, organized under the laws of the state of Illinois and located in part in the city of Chicago, and in the county of Cook, in the state of Illinois, and a citizen of the state of Illinois.' The remedy sought for is an injunction restraining the defendants from receiving or permitting any sewage to be received or discharged into the artificial channel or drain constructed by the Sanitary District, under authority derived from the state of Illinois, in order to carry off and eventually discharge into the Mississippi the sewage of Chicago, which had been previously discharged into Lake Michigan, and from permitting the same to flow through said channel or drain into the Des Plaines river, and thence by the River Illinois into the Mississippi. The bill alleged that the nature of the injury complained of was such that an adequate remedy could only be found in this court at the suit of the state of Missouri. The object of the bill was to subject this public work to judicial supervision, upon the allegation that the method of its construction and maintenance will create a continuing nuisance, dangerous to the health of a neighboring state and its inhabitants, and the bill charged that the acts of the defendant, if not restrained, would result in the transportation, by artificial means, and through an unnatural channel, of large quantities of undefecated sewage daily, and of accumulated deposits in the Harbor of Chicago, and in the bed of the Illinois River, which will poison the water supply of the inhabitants of Missouri, and injuriously affect that portion of the bed or soil of the Mississippi River which lies within its territory. The bill did not assail the drainage canal as an unlawful structure, nor aim to prevent its use as a waterway; but it sought relief against the pouring of sewage and filth through it by artificial arrangements into the Mississippi River, to the detriment of the state of Missouri and its inhabitants. The defendants demurred to the bill for want of jurisdiction and for reasons set forth in the demurrer. This court held that the demurrer could not be sustained, and required the defendants to appear and answer."

Accordingly, an answer was filed in the case, and a vast volume of evidence was taken, including much expert testimony as to the effect of sewage on the water and health, and the Supreme Court, after elaborately reviewing the evidence, decided that the evidence was insufficient to sustain the bill, and therefore dismissed the cause without prejudice. In concluding the opinion, Judge Holmes, speaking for the court, said: "We might go more into detail, but we believe that we have said enough to explain our point of view and our opinion of the evidence as it stands. What the future may develop, of course, we cannot tell; but our conclusion upon the present evidence is that the case proved falls so far below the allegations of the bill that it is not brought within the principles heretofore established in the cause."

It will be seen that two important questions were decided in these decisions: (1) That the court had jurisdiction to hear and determine the controversy between the state of Missouri and the state of Illinois; and (2) that the bill stated facts which, if clearly and fully established by the evidence, would entitle the plaintiff to relief.

The English courts have uniformly held this doctrine, and this rule is clearly stated in the case of Atty. Gen. vs. Leeds, L. R. 5 Ch. 583, 588, 596. It appears that in England the protection of property from appropriation for public use without compensation does not depend on any fundamental law, but upon inherent justice, and the principle is carefully recognized in all legislation authorizing an infringement of private rights. So the legislative authority for emptying the sewage of cities into water courses and rivers is coupled with the provision that no nuisance is thereby authorized. Such legislation protects private rights in a manner similar to our constitutional legislation. The city of Leeds, having obtained an act of Parliament for emptying its sewage into the River Aire, claimed that the usual protection was not included in the act, and therefore the city was not responsible for nuisances maintained under an act of Parliament, urging the same plea of necessity pressed in this case. James, V. C., held that the act would not bear the construction claimed, and said he would be bound to put any construction on the act "which would prevent such a monstrous injustice." This decision was affirmed by the Appellate Court; Giffard, L. J., saying: "In construing the act, one must always consider that, if it had a different meaning, it would be against common sense."

In Carmichael vs. City of Texarkana 94 Fed. 561, it was held that: "A municipal corporation, though authorized by statute to construct sewers, has no right to so construct its system as to discharge sewage on the lands of an individual, or in such place that it flows on his lands and pollutes a water course thereon, or otherwise creates a nuisance by which he suffers damage."

Attention was called by the Guthrie counsel to the decisions of the Supreme Court of Indiana, which seems to uphold the theory of the city. The leading case is that of the City of Valparaiso vs. Hagen, 54 N. E. 1062, decided Oct. 25, 1899. It appears from the opinion that the city of Valparaiso was then a city of 8,000 inhabitants. Salt creek is a natural water course flowing from south to north through the western part of the city, and thence west and north, to its confluence with the Calumet River. Its fall is 15 ft. per mile, and its minimum volume 227 cu. ft. of water per minute. Within the city limits on the southwest is a low-lying marsh that naturally drains into Salt creek. The natural and only practicable drainage for all the territory within the city limits is Salt creek. Prior to 1896 the city had constructed, according to law, a general and complete system of sewerage for the city, at a cost of $50,000, and 200 closets and 500 kitchens had been connected therewith, and the outfall from the entire system was into the marsh at the southwest, at a point about 64 rods from Salt creek. About 47,000 gal. of sewage were daily discharged into the marsh. The marsh was heavily overgrown with grass and other vegetation, but sewage in some form found its way into Salt creek and polluted its waters. Above the point of sewage contact there were three slaughter houses that drained directly into Salt creek, and one rendering establishment and one gas works drained into nearby tributaries. Nine-tenths of 1 per cent. of the water in Salt creek below the sewer discharge in time of low water was sewage coming from the city, the slaughter houses, and other polluting agencies above. The appellant had arranged for an extension of the outlet directly through the marsh to Salt creek. The plaintiffs, nineteen in number, were the owners and occupants of lower lands abutting on Salt creek at distances from two to ten miles from and below Valparaiso. The action was for an injunction precluding the city from discharging sewage into Salt creek. In this case it was held:

"(1) A city will not be enjoined from discharging its sewage in a natural water course, where it acts skillfully and in conformity to the statute, and is free from negligence, though the waters are polluted to the injury of lower riparian proprietors, where there is no other natural or reasonable possible means of drainage. (2) The act of a city in draining its sewage in a stream, thereby so polluting its waters that they destroy the pastures of a lower riparian proprietor in flood time and emit noxious odors to his personal injury, is not such a taking of private property for public use as must be preceded by just compensation. (3) Injunction will not lie to restrain the exercise lawfully conferred on a city to construct a sewer until it has been abused to the injury of a public or private right." It will be observed that this was an action of injunction to restrain the city from maintaining its sewer system, and not an action for damages by a property owner who was injuriously affected thereby. Two points were decided by the court: (1) That injunction in such circumstances will not be awarded; and (2) that the maintenance of such a sewer, no part of the premises having been invaded, did not constitute the taking of private property for public use to such an extent as must be preceded by just compensation. And, upon a close analysis of this case, it will be seen that the Supreme Court of Indiana did not decide that a property owner whose health was injured or impaired, and whose property was damaged, could not maintain an action, and recover damages for such sum as the facts and circumstances might warrant.

In the case of City of Valparaiso vs. Moffit, 39 N. E. 909, the Appellate Court of Indiana seems to hold that the city is liable in damages for discharging sewage into a stream; but in the case of City of Richmond v. Test, 48 N. E. 610, the same court holds that the city is not liable under such circumstances. It is difficult to reconcile these conflicting decisions of the Indiana courts. In the case last mentioned, the decision appears to be based upon the theory that cities are not liable for consequential damages resulting from the construction, maintenance, or operation of sewers, streets, or other public works, in the absence of negligence, and where due care and skill are exercised, and the court quotes with approval the decision of the Supreme Court of the United States, in Transportation Company vs. Chicago, where it was held that, where the law authorizes a municipal corporation to construct a public work, it cannot be guilty of maintaining a nuisance so as to give a common-law right of action but, Judge Hainer says, the decision of the Supreme Court, while it held that that which the law authorized could not constitute a nuisance, is not in conflict with the cases cited in support of his opinion.

The construction of the sewer in the Guthrie case could not constitute a nuisance, because the statute authorized the construction of the sewer within the limits of the city; but this does not authorize the city to maintain its sewer in such a manner as to create or constitute a nuisance to the detriment of the peace, health and repose of an individual citizen, whose rights may be injuriously affected thereby.

From a careful examination and consideration of these authorities, and many others, Judge Hainer reached the conclusion: (1) That the settled doctrine of the English courts, as well as some State courts, is that a lower riparian proprietor is entitled to recover damages for the pollution of the waters of a stream by a municipal corporation, by the discharge of sewage into the stream, on the broad ground of common sense and natural justice; (2) that the Supreme Court of the United States and a number of the State courts base their decisions on the ground that it is a taking of private property for public use, within the meaning of the federal Constitution; (3) that other States hold that it is a damage to property, within the meaning of their constitutional inhibitions against the taking or damaging of property without just compensation; and (4) a number of the States hold that the lower riparian proprietor is entitled to recover damages for injury to his health, comfort and repose on the ground that it is the maintenance of a nuisance. While these decisions are based upon different ground, yet, upon whatever ground they may rest, they all, with the exception of the decisions of the Indiana courts, seem to uniformly hold that, under such circumstances, damages are recoverable, and many of them hold that, where the evidence is clear and convincing, injunction will lie to restrain the continuance of the nuisance.

THE STATE RAILROAD COMMISSION of Washinton has begun to take testimony on the cost of construction and reproduction of the railroads of the State.

Automatic Gas Control for Producers.

In a paper on the application of gas power to central-station work which Mr. J. R. Bibbins presented before the National Electric Light Association recently, reference was made to a method of automatic gas control employed on all Westinghouse producers. As the steam boiler operates on a constant-pressure system, so does the producer, and in addition on a constant quality of gas. But, whereas steam is enormously expansive as compared to feed-water, the volume of gas made is practically proportional to that of the air blast. A steaming boiler has large storage capacity which tides it over sudden demands until the fire can respond; in the producer, the blast must follow the changes in output, volume for volume. With hand regulation this is difficult, if not impossible, without the intervention of auxiliary storage in the shape of a gas holder. In the intermittent type of plant producing water and air gas alternately, which for power purposes must be thoroughly mixed, a holder is an absolute necessity; but in the continuous-blast plant the holder is not necessary if automatic control of gasification is provided.

The seat of control in the Westinghouse apparatus is the pressure at the nozzle of the steam injector blower supplying air to the producer. This steam supply is varied by throttling according to the demand for gas through the action of a pressure regulator, which may be either of the diaphragm or of the gasometer type, and is connected to the main header supplying gas to the engines. As the demand for gas increases, the pressure falls and the regulator opens the throttle of the blower until enough gas is made to bring the pressure back to normal. These changes take place almost constantly, but without violent fluctuations.

Tests were recently made at East Pittsburgh to prove the action of this regulator. A by-pass to the atmosphere was used to obtain wide ranges of producer output, as well as instantaneous changes. With the exception of a slight "wink" due to valve opening or to charging coal, the regulator held the gas pressure to within half an inch of mean pressure, even when instantaneously loading and unloading the producer, which is the severest test that could be found. It must be remembered that gas engines are equipped with individual pressure regulators to insure gas at atmospheric pressure at the mixing valves. Although these are still provided in the field, it has been found possible, and it is now the practice on the test floor at East Pittsburgh, to run engines on test with only the producer regulator in the line, which holds the gas pressure sufficiently uniform to maintain the proper mixture.

The variation in the output of the producer by this regulator has no noticeable effect on the heat value of gas. During the 2-hour test, the value per cubic foot averaged 131 B. t. u., varying only 3.75 per cent., from the mean. Variation in output proved to be a function of the regulator movement, and consequently the blower pressure. That it is not a linear relation is due entirely to the characteristics of the injector type of blower, in which the velocity of steam and the resulting entrainment of air is proportional to the square of the pressure head. This apparatus, in doing away with the gas holder with the extra ground space and piping necessary, reduces the producer plant to its simplest form—producer and scrubber in one self-contained unit.

THE NEW METTALURGICAL LABORATORY at Yale University, Hammond Hall, the gift of Professor John Hays Hammond, has recently been finished. The laboratory contains a complete concentrating plant, stamp mill, cyanide plant, assaying rooms, and other equipment for instruction in all branches of metallurgical work.

Rates for Water Service.

Presidential Address of Mr. Dabney H. Maury, president of the American Water-Works Asssociation.

The proper fundamental basis for all rates for water service is that the rates, when established, should be fair. In what follows, an effort will be made to outline the principles which should govern the determination of the fair rate. As these principles are the same for municipally-owned plants as for private ones, no distinction will hereinafter be made between the two.

Before the rates may be termed fair, these two conditions must obtain: First, the total yearly receipts from all sources must be just sufficient to provide (*a*) reasonable interest on the investment; (*b*) annual contribution to sinking fund to retire investment within a reasonable time; (*c*) proper annual contribution to sinking fund for depreciation; (*d*) legitimate operating expenses, including repairs. Second, each consumer must pay yearly, for the particular class of service that he receives, his just proportion of the above annual costs. To fulfill the second condition, no service of any sort whatever should be furnished free.

It may be said that, in practice, neither of these two conditions can ever be realized with absolute exactness, and obviously the second is far more difficult to approximate than the first; but these considerations can in no way affect the fundamental principles involved.

A water-works plant is almost always designed to supply fire protection as well as the water required for ordinary consumption.

Manifestly, the first cost and operating expenses of a plant built only to supply water for ordinary consumption are very much less than those of a plant which also furnishes fire protection.

An average of available estimates made by eminent authorities shows that the annual cost of furnishing fire protection under average conditions is about 50 per cent. of the interest and other fixed charges due to cost of construction of the works, and about 20 per cent. of the annual operating expenses.

Fair rates would, therefore, make the receipts from fire-protection service sufficient to cover 50 per cent. of the fixed charges and 20 per cent. of the operating expenses, the balance of 50 per cent. of fixed charges and 80 per cent. of operating expenses being provided by the rates for water supplied for ordinary consumption.

Fire-protection service may properly be divided into two classes: Public fire protection, or that provided by the public fire hydrants on the streets; and private fire protection, which is afforded to the owners of factories, stores, warehouses, or the like, by means of special service pipes of large size connected with the water department's distribution mains.

Pursuant to the second essential condition of a fair rate, neither class of fire protection should be furnished free, and the sum of all receipts from both classes should equal the annual expense properly chargeable to the fire-protection feature of the works.

In practice, payments for public fire protection may best take the form of hydrant rentals; and whether the plant is municipally or privately owned is wholly immaterial in this connection. In either case, the water department is presumably a business concern, operated on a purely business basis, and it should receive the proper rates for public fire protection, paid out of the public funds.

There are abundant reasons why rates should be paid for private fire protection. The owner of the factory or other establishment so protected receives not only a yearly cash benefit measured by the reduction of his insurance premiums, but also a further substantial benefit in the form of protection against loss of business or other fire loss not covered by insurance. This latter benefit, while not so easy to measure in dollars and cents, is often of greater value than the actual reduction in premiums.

The factory owner may argue that the same service connection which lessens his individual fire hazard also lessens to some extent the conflagration hazard of the community; but when all the facts are considered, this cannot well be said to be the case. The openings on his fire protection service are on his premises, and most of them are inside his buildings. They are not accessible for use by other parties. Should he happen to be dishonest enough to do so, he could draw, without detection, large quantities of water for uses other than fire protection. Should a fire once gather headway on his premises, enormous amounts of water might be drawn from thousands of sprinkler heads, or as a result of the breaking of his large service pipes by falling walls, or in other ways and the quantity of water so drawn might readily be enough to seriously hamper the city fire department in its efforts to check a conflagration. To sum up, the factory owner may be said, in effect, to benefit exclusively, and to a substantial extent, by reason of a special service which the water department is at expense to provide, and for which he should therefore pay.

It is not possible to satisfactorily meter his fire service; and if it were, to base his rate on the value of the water actually consumed to extinguish fires would be as unreasonable as it would be to say that the value of a navy is nothing more than that of the ammunition which it expends in actual warefare.

The fixing of rates for private fire protection is so intricate a problem, and involves consideration of so many points, that no fixed rule can be laid down that will fit all cases. It is believed that a reasonable sliding scale of rates for such service might be arrived at as follows: A minimum rate for the smallest size of fire service pipe, and larger rates for larger service pipes, the rates for each size of fire service pipe to bear some approximately uniform relation to the special benefits derived by the private interests protected.

Rates for water for purposes other than fire protection are of two general classes, fixture rates and meter rates. Originally all water was sold at fixture rates, but the necessity for checking waste, and the recognized inequity of fixture rates as applied to individual cases, have brought about the introduction of meters, which is now going on at a constantly increasing speed.

The earliest fixture rates were necessarily established largely by guess; and later ones have been fixed, sometimes by taking the average, and sometimes by picking out the lowest of all the guesses made by previous guessers. Little or no account was usually taken of the differences in cost of furnishing water in different locations and under varying conditions.

That fixture rates are not now, as a rule, excessive is indicated by the fact that when all legitimate expenses are charged up, few municipally-owned plants earn large profits, and that the securities of private water companies are no longer so eagerly sought by investors as they were some years ago. The objection to fixture rates as a basis of the value of water service does not lie in the fact that they cannot be made, in the aggregate and for any one city, as a whole, as equitable as any other rates; for this is not only possible, but is a condition which actually obtains, within reasonable limits, in many cities. But with fixture rates, no close discrimination can be made between individual cases; and they therefore fail to fulfill the second essential condition of a fair rate. Furthermore, they fail to check waste and leakage. These considerations naturally lead to the adoption of meter rates.

In almost every city, the introduction of meters, if accompanied by the establishment of proper rates, can be made to result in benefit to the water department as well as to the consumer; and it is possible, with meters, to make a closer approximation to the fair amount to be paid by each individual consumer than can be made without them.

The cost of the introduction of meters, and of their subsequent maintenance and operation, will, with proper rates, be more than offset, and without hardship to the consumer, by the savings in pumping expenses and in the costs resulting from extensions to plant, which would otherwise have to be made.

The function of the meter is two-fold: First, to check waste, and, second, to measure the water used by each consumer, with a view to making his annual payments bear a just proportion to the total fair annual receipts from the works. To treat the meter simply as a device by means of which certain individual consumers may reduce their rates below the fair amount, leaving other consumers to make up the loss, is to defeat its honest purpose.

In order that the meter may properly perform its two-fold function, it is absolutely essential that the meter rates be established on a proper basis. In view of the ever-increasing use of meters, no more vital problem to-day confronts the manager of a water department than the determination of what these rates should be in his city; and it is a problem whose solution demands the very highest degree of skill, careful study of all the conditions and a wide experience in the financial mangement of water works.

Nothing is more fallacious than the oft-repeated argument of some unthinking advocates of the universal introduction of meters, that when a man buys water by the gallon he pays for what he gets.

Each consumer, whether he use little or much water, enjoys the benefit of a water service, always at hand, always convenient. This benefit is the element which is usually termed the "readiness to serve," and the expense to the water department of its readiness to serve is always far greater than the mere cost of pumping and distributing water. Furthermore, the fixed charges and operating expenses for each meter service amount to several dollars per annum; and this expense, together with a sum sufficient to cover the "readiness to serve," is properly chargeable to each consumer, large or small, before the rate per gallon can fairly begin to apply.

To provide for these two expenses, the first method which naturally suggests itself is the establishment of a minimum meter rate.

Here, again, there is a pitfall. If this minimum be too small, it will not accomplish its purpose. If it be too large, or if the rate per gallon for small daily uses be too small, the average domestic consumer may draw far more water than he actually needs without paying more than the minimum rate; and this condition will destroy the usefulness of the meter as a means of checking waste.

To set meters wholesale, without due regard for the foregoing facts, would not only work an injustice to some classes of consumers, but might mean financial disaster to the water department; and this in turn would be a misfortune to the whole community.

To develop the full efficiency of the meter as a means of checking waste, and to make each consumer, large or small, pay his fair share of the total receipts of the work, meter rates should be established about as follows: (*a*) The minimum rate should be nearly large enough to provide for the "readiness to serve," as well as for the added expense of the meter service. (*b*) There should be a sliding scale of rates for measured water. (*c*) The highest rates in this scale should be so adjusted that the average domestic consumer could draw, without exceeding his minimum rate, only enough water for his reasonable requirements, so that the incentive to avoid waste might always be present; and the lowest rates in the scale should be such as to encourage large consumers to patronize the water department, the profits from this patronage being, of course, ultimately applicable to the lowering of rates to all consumers.

From all of the foregoing, it will be seen that rates of all classes are co-related. The total receipts should just provide for the total legitimate expenses, as enumerated in the definition of the first essential condition of a fair rate. Each class of service should be made to furnish its quota of the total receipts from all classes of services; and each individual consumer should pay his just proportion of the total receipts from the class to which he belongs.

It is admitted that this ideal state of affairs can never be fully realized in actual practice. But many notable instances of mistakes already made in the establishment of rates, furnish abundant proof that a careful, sane and intelligent study of conditions will do much towards approximating the desired results.

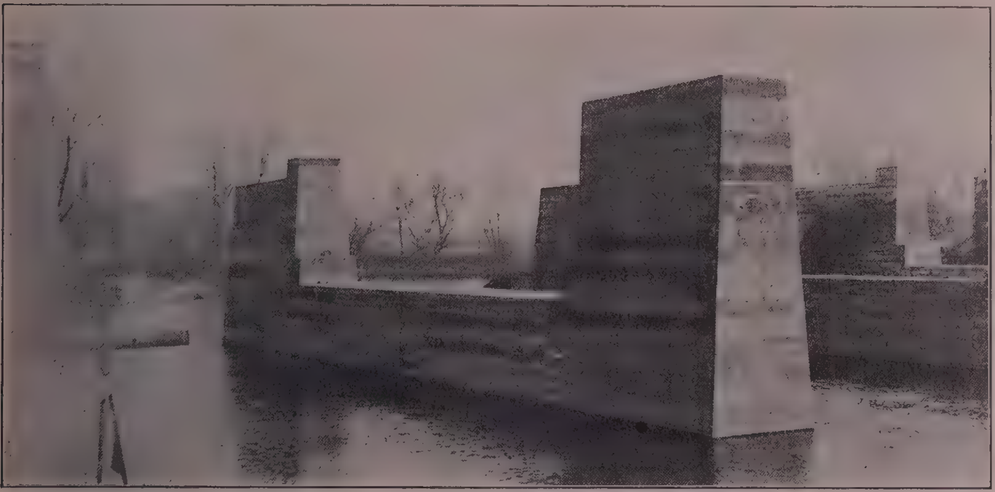
THE RISKS OF TRENCH EXCAVATION were recently discussed by Judge Willard Bartlett, of the New York Court of Appeals, in deciding a suit brought by a laborer named Citrone against the O'Rourke Engineering Construction Co., 80 N. E. Rep., 1092. The company was excavating a rock trench about 14 ft. deep and 7 ft. wide, and Citrone was a member of the gang which cleaned up the trench after each blast had thrown down some rock. He was injured by rock and earth falling on him, probably loosened by a blast about two hours earlier, and sued for damages on the ground that he was not provided with a reasonably safe place in which to work. Judge Bartlett rules, and the other justices agree, that the danger to which the men were exposed was due to the nature of the work. The degree of safety near the head of the trench was constantly subject to change as the excavation progressed, and the rule of law which makes it incumbent upon an employer to provide or maintain a safe place in which his men are to work is inapplicable. "The principle of a safe place does not apply where the prosecution of the work itself makes the place and creates its danger. . . . The rule that the master must provide a safe place for work only applies where the work and the place are not connected, where the work is not in the construction of the place, as in the case of a mill, a factory, mine, ship or well."

Aqueduct Bridges on the Illinois and Mississippi Canal.—II.

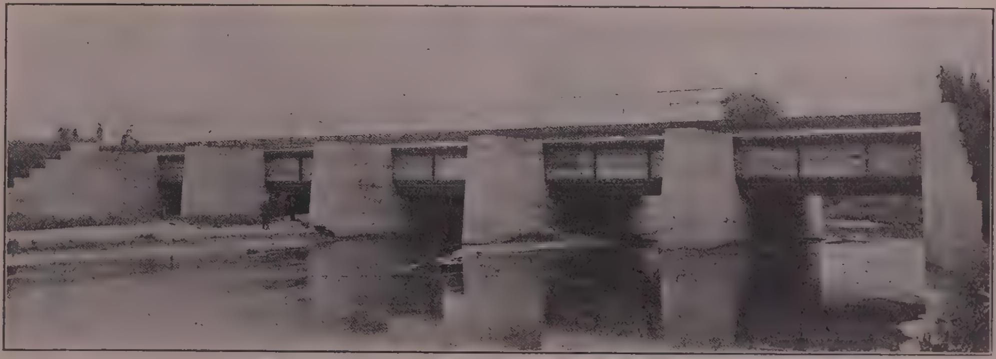
By Fred W. Honens, M. Am. Soc. C. E., Junior U. S. Engineer.

The Illinois and Mississippi Canal is carried over the more important streams by means of aqueduct bridges, varying in length from 4 to 10 spans, each span being 35 ft. in length. There are nine aqueducts in all. Nos. 1, 2 and 3 are on the Eastern Section, Nos. 4 to 8, inclusive, are on the Western Section, and No. 9 is on the navigable feeder.

Design.—The general design of the aqueducts is the same, but the details are somewhat different. For instance, Aqueducts 1, 2 and 8 connect with Locks 4, 12 and 27, respectively, and have but one abutment; Aqueduct 9 has an emergency gate at each end; and several of the aqueducts are provided with needle dams at the ends and flap valves through the floor with which to equalize the pressure during a flood, when the canal is unwatered.


Pier at Aqueduct No. 8.

View of Completed Lining of Aqueduct No. 8.


General View of Aqueduct No. 9 after Completion.

The piers and abutments are concrete structures supported on a concrete filled grillage resting on piles. An opening is left through the masonry to receive the trunk, which is built of structural steel, lined with reinforced concrete.

The piers are 77 ft., 10 in. long, 4 ft. wide on top, 6 to 8 ft. wide at the foundation, and vary in height from 19 to 30 ft. The top of the masonry is 2 ft. above the water level in the canal. The downstream end is vertical and square, while the upstream end is inclined and brought to an edge to form an ice breaker.

Through the center of the pier an opening 44 ft. 4 in. wide and 11 ft. deep is left to receive the trough or bridge. The concrete around this opening is reinforced with two 1½-in. steel rods laid horizontally and two vertical rods on each side.

The abutments have a top width of 4 ft. and are from 100 to 115 ft. long. The ends are stepped down to meet the embankment slopes and are set at an angle of 30 deg. with the face. An opening of the same dimensions as for the piers is left for the trough, the abutment being constructed so as to make the inside of the lining flush with the masonry, which is extended back 19 ft. at right angles to the face so as to catch the inside of the canal embankments. The wall between the two symmetrical L-shaped portions is a sort of breast wall, which retains the earth below the bottom of the canal and supports the floor of the lining.

The approaches to the aqueducts are paved with concrete, splaying from the vertical retaining walls of the abutment to the 1 to 2 earth slope of the embankment in a distance of 40 ft.

The foundations for piers consist of three rows of hardwood piles (25 piles in a row) capped with 10 x 10-in. longitudinal pine timbers on which are placed 6 x 10-in. by 8 ft. cross timbers spaced 2 ft. between centers. The longitudinals are fastened to the piles with 1 x 22-in. drift bolts and to the cross timbers with ¾ x 18-in. drift bolts. The spaces between timbers is filled with a natural cement concrete.

The foundations for the abutments are practically the same as for the piers, except that an extension is made for the embankment retaining walls and lines of triple-lap oak sheeting are driven at front and back of the foundation. The piling is made of three pieces of 1½-in. white oak plank, which are fastened to 4 x 12-in. oak waling timbers

The trough or trunk consists of a steel superstructure lined with reinforced concrete. It was originally planned to line the trunks with wood but upon further investigation it was found that a lining of reinforced concrete would better meet the requirements, that its first cost would be less, and it is believed that the cost of maintenance will not be so great. The concrete lining was designed by Assistant Engineer L. L. Wheeler.

The clear width between waling timbers is 39½ ft., the depth for water is 7 ft. 4 in., and the distance between centers of piers is 35 ft.

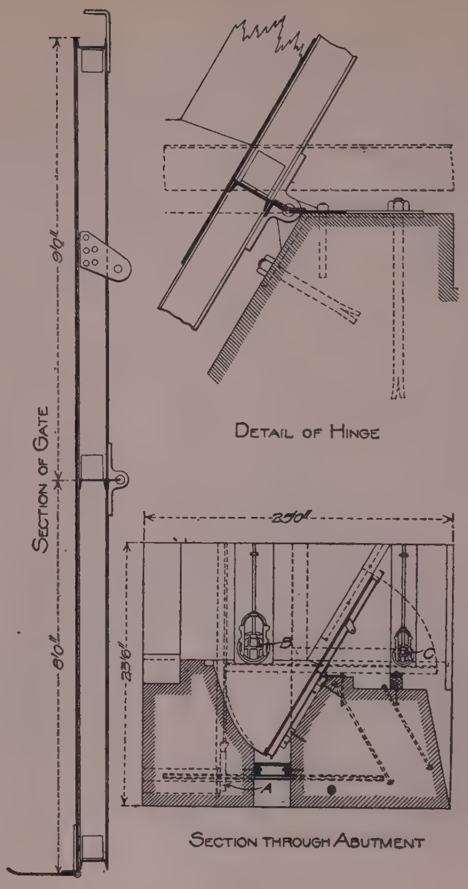
There are 19 90-lb. I-beams, spaced 2 ft. 3 in., in the floor, which are held in position by four 1¼-in. rods with turnbuckles and cast-iron separators between the beams. In each side, there are two 90-lb. I-beams, spaced 6 ft. 7 in., which are connected with 1¼-in. rods and 10-in. 15-lb. channels, forming three-panel vertical trusses.

The floor lining is 6 in. thick, extending 2 in. below and 4 in. above the top of the floorbeams. It is reinforced with two ½-in. old-style Johnson corrugated bars, lying longitudinally in the space between floorbeams, and the same bars laid crosswise and spaced 6 in. between centers throughout the length of one span of the aqueduct.

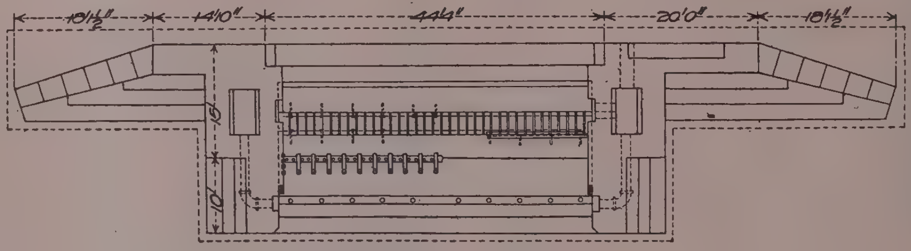
At the corners, betwen the sides and the bottom, the lining is strengthened with additional concrete, having a triangular section 3 ft. on a side.

The lining on the sides is 9 in. thick, reinforced with ¾-in. old-style Johnson bars, 9 ft. long, spaced 6 in. between centers, extending from the top of the wall into the floor lining, being bent so as to lap the horizontal cross rods in the floor about 2 ft. The longitudinal reinforcing consists of nine ½-in. bars and thirteen ¾-in. bars.

Fenders, made by bolting two 12 x 12-in. and one 6-in. pine timbers together, making a beam 30 in. deep, are anchored to the inside of the piers to protect the lining.

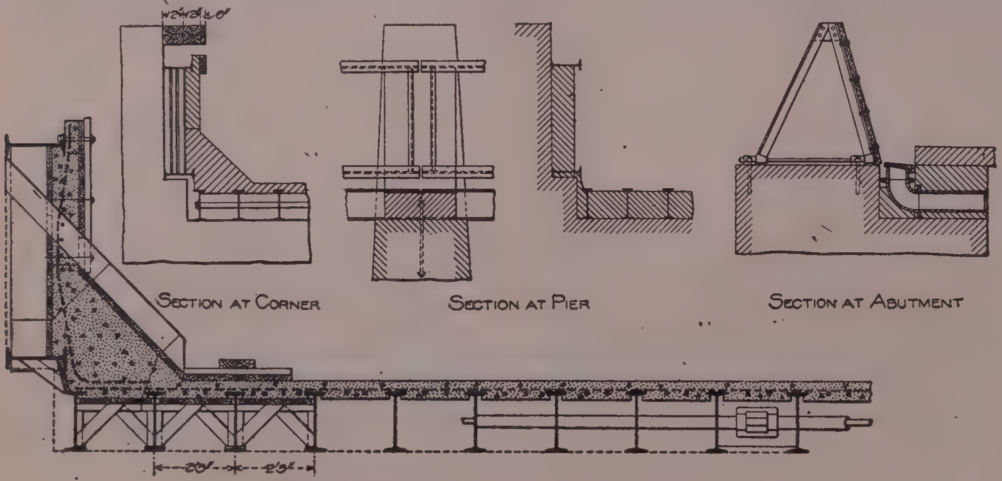


Details of Emergency Gate.



Masonry Plan, Aqueduct No. 9.

As the canal has been built so that animal traction may be used if desired, a tow path bridge is carried over one end of the piers. It consists of four 42-lb. 10-in. I-beams and one 33-lb. channel fastened together with four 1-in. rods and 1¼-in. gas pipe separators and covered with two thicknesses of 2-in. pine. There is a steel railing on the outside.



Reinforced Concrete Lining for Aqueducts.

At high water, some of the streams rise above the bottoms of the aqueducts and if the canal should be unwatered at such a time the floors would be subjected to an upward pressure. To relieve this condition, small dams have been constructed at each end of the aqueduct and a flap valve set in the masonry to allow the aqueduct to fill to the outside water level.

These dams consist of ten A-shaped trestles placed 4 ft. between centers, which support 2 x 12-in. plank laid horizontally. The trestles are 4 ft. high, 3 ft. 3 in. wide at the base and are made of 3 x ⅜-in. angles. They revolve about a horizontal shaft 1-in. in diameter, supported by two cast-iron pillow blocks, which are anchored into the masonry of the abutments. When not in use, the trestles lie below the bottom of the aqueduct.

There are about 40 miles of canal between the feeder guard lock, at the entrance from Rock River, and the first lock on each side of the junction of the feeder and the main line of the canal. If a break should occur in the banks of this part of the canal, considerable damage might be done. In order to reduce the amount of water that would be discharged if such an accident should occur, emergency gates of the Des Fontaine type have been provided at each end of Aqueduct 9, which divides this distance into two almost equal parts. The gates are built of structural steel and are operated in the abutments by hydrostatic pressure.

The masonry of the abutments was made considerably larger than those of the other aqueducts to accommodate the emergency gates, the length along the canal being 25 ft. instead of 19 ft.

The breast wall is 25 ft. wide and is reinforced at the bottom with old 30-lb. rails 18 ft. long, laid crosswise every 3 ft. and with 2-in. inclined anchor bolts every 2 ft. It contains a chamber extending its full length, 41 ft., in which the lower leaf of the gate operates. Below this opening is a passageway which connects with a well hole in each of the L-shaped portions of the abutments.

There are three other openings into the wells, one to Green River, one from the aqueduct trough above the gate, and one from the canal back of the gate, these openings being designated in the illustration by the letters A, B and C, respectively. A and B are closed by circular sluice valves, 24 in. in diameter, with non-rising screws, which are operated from the top of the masonry with socket wrenches with hand wheels. The bypasses, C, are closed with shear valves, 12 in. in diameter. The valves were made by the Chapman Valve Manufacturing Co.

The gate is 40 ft. 11 in. wide, 17 ft. deep, having two unequal leaves, the upper leaf being 9 ft. deep and the lower leaf, 8 ft. It consists of 21 7-in. 20-lb. I-beams, spaced 2 ft. between centers, sheathed with a ⅜-in. cover plate. Each I-beam has a wrought-iron hinge securely bolted to it, 6 in. below its center, which is anchored to the masonry with two 1½-in. fox bolts, 18 in. and 32 in. long.

A pair of plates forming a sort of clevis are riveted to each beam about 4 ft. above the hinge and are connected by a 1-in. dredge chain to the eye of a 2-in. anchor bolt, 7½ ft. long embedded in the masonry. The chain can be adjusted for length by the clevis by which it is fastened to the eye-bolt.

The beams are connected at the bottom and at the top with a 7-in. 14.75-lb. channel, extending the full width of the gate, and at the hinges with short channels of the same size.

Plates bent at right angles are riveted at upper end of beams to receive old rails for ballast, if needed.

A steel plate or mud guard is hinged to the bottom of the cover plate to make a connection between the gate and masonry.

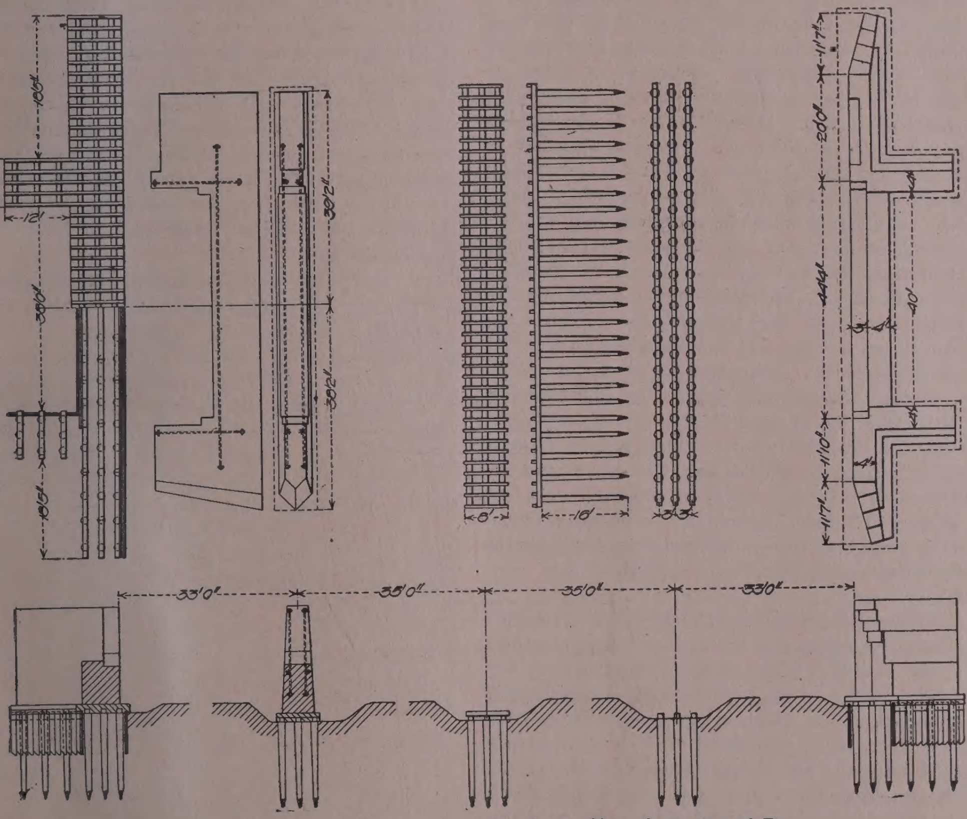
Rubber packing is used to prevent excessive leakage. The joint at the hinge is made by bolting a 3 x 3 x ⅜-in. angle extending between adjacent hinges, to the channel that connects the I-beams. The end of one leg of the angle is ⅛ in. from the center of the axis of the hinge. A ⅜ x 9-in. plate is anchored to the masonry with its edge at the center of this axis, and a piece of ⅜-in. rubber packing is bolted to the angle and covers the opening between the plate and angle.

There is a clearance of ½-in. between the gate and masonry, which is closed on the lower leaf by bolting two pieces of ¼ x 3-in. packing to the underside of the sheeting. Steel straps, 2½ x ⅜ in., are placed on the outside of the packing, through which the bolts extend.

Normally, the gate lies in a horizontal position, as shown in the illustration by dotted lines, and rests upon an oak sill 16 in. high, being held by the excess of weight of the upper leaf over the lower leaf. When the gate is up, it stands at an angle of 60 deg. with a horizontal plane.

In case of accident to the canal banks, the gate nearest the break is operated; that is to say, the gates are raised against the current that would be developed under such a condition.

To raise the gate, the lower valve, A, is opened, allowing the water under the gate to escape into the river channel. This relieves the pressure under the lower leaf and a force equal to the weight of the water over that portion of the gate is developed, which tends to rotate the gate on its axis. The force is resisted by the excess weight of the gate and the current acting on the upper leaf. If the lower valve is not entirely opened, the gate will rise very slowly and close against inclined oak sills at the sides of the upper leaf and onto a sill under the lower leaf. To lower the gate the lower valve, A, is closed and the upper valve, B, is opened, allowing the operating chamber to fill,, when the gate gradually settles into its normal horizontal position.



Foundations and Masonry. Aqueducts Nos. 4, 5, 6 and 7.

Anticipating the possible operation of the gate farthest from the break, in which case the gate would rise with the current, each I-beam is provided with a 1-in. dredge chain, which is attached by a standard clevis to the eye of a 2-in. anchor bolt, embedded in the concrete. The bypasses would be used in such emergency to close the gate.

(To Be Continued).

A SINGLE-LEAF BASCULE BRIDGE of 150-ft. span has been built over the south branch of the Chicago River for the use of the Illinois Central, the Santa Fe, and the Chicago & Alton railroads. It was built under the Page & Schnable patents. The angle of the river to the bridge is 68½ deg. and the clear channel is 100 ft. wide.

Nomenclature and Specifications for Structural Timber.

The Committee on Standard Specifications for the Grading of Structural Timber reported at the recent meeting of the American Society for Testing Materials its final conclusions regarding certain portions of its work, and these conclusions will be issued to letter ballot shortly, which it is reasonable to anticipate will be in favor of their adoption. They read as follows:

Standard Defects.—Measurements which refer to the diameter of knots or holes should be considered as referring to the mean or average diameter.

1. Sound Knot.—A sound knot is one which is solid across its face and which is as hard as the wood surrounding it; it may be either red or black, and is so fixed by growth or position that it will retain its place in the piece.

2. Loose Knot.—A loose knot is one not firmly held in place by growth or position.

3. Pith Knot.—A pith knot is a sound knot with a pith hole not more than ¼ in. in diameter in the center.

4. Encased Knot.—An encased knot is one which is surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ in. in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot.

5. Rotten Knot.—A rotten knot is one not as hard as the wood it is in.

6. Pin Knot.—A pin knot is a sound knot not over ½ in. in diameter.

7. Standard Knot.—A standard knot is a sound knot not over 1½ in. in diameter.

8. Large Knot.—A large knot is a sound knot more than 1½ in. in diameter.

9. Round Knot.—A round knot is one which is oval or circular in form.

10. Spike Knot.—A spike knot is one sawed in a lengthwise direction; the mean or average width shall be considered in measuring these knots.

11. Pitch Pockets.—Pitch pockets are openings between the grain of the wood containing more or less pitch or bark. These shall be classified as small, standard and large pitch pockets. A small pitch pocket is one not over ⅛ in. wide. A standard pitch pocket is one not over ⅜ in. wide, or 3 in. in length. A large pitch pocket is one over ⅜ in. wide, or over 3 in. in length.

12. Pitch Streak.—A pitch streak is a well-defined accumulation of pitch at one point in the piece. When not sufficient to develop a well-defined streak, or where the fibre between grains, that is, the coarse-grained fibre, usually termed "spring wood," is not saturated with pitch, it shall not be considered a defect.

13. Wane.—Wane is bark, or the lack of wood from any cause, on edges of timbers.

14. Shakes.—Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

15. Rot, Dote and Red Heart.—Any form of decay which may be evident either as a dark red discoloration not found in the sound wood, or the presence of white or red rotten spots, shall be considered as a defect.

16. Ring Shake.—An opening between the annual rings.

17. Through Shake.—A shake which extends between two faces of a timber.

Names for Structural Timbers.—Southern Yellow Pine.—Under this heading two classes of timber are used: (*a*) longleaf pine, (*b*) shortleaf pine. It is understood that these two terms are descriptive of quality, rather than of botanical species. Thus shortleaf pine would cover such species as are now known as North Carolina pine, loblolly pine and shotleaf pine. Longleaf pine is descriptive of quality, and if Cuban, shortleaf or loblolly pine is grown under such conditions that it produces a large percentage of hard Summer wood, so as to be equivalent to the wood produced by the true longleaf, it would be covered by the term "longleaf pine."

2. Douglass Fir.—The term "Douglas fir" to cover the timber known likewise as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, Northwest and West coast fir.

3 Norway Pine, to cover what is also known as red pine.

4. Hemlock, to cover Southern or Eastern hemlock; that is, hemlock from all States east of and including Minnesota.

5. Western Hemlock, to cover hemlock from the Pacific coast.

6. Spruce, to cover Eastern spruce; that is, the spruce timber coming from points east of Minnesota.

7. Western Spruce, to cover the spruce timber from the Pacific coast.

8. White Pine, to cover the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.

9. Idaho White Pine, the variety of white pine from Western Montana, Northern Idaho and Eastern Washington.

10. Western Pine, to cover the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as Western Yellow Pine, or Ponderosa Pine, or California White Pine, or Western White Pine.

11. Western Larch, to cover the species of larch or tamarack from the Rocky Mountain and Pacific coast regions.

12. Tamarack, to cover the timber known as Tamarack, or Eastern Tamarack, from States east of and including Minnesota.

13. Redwood, to include the California wood usually known by that name.

Standard Specifications for Bridge and Trestle Timbers.—To be applied to solid members and not to composite members. Except as noted, all timber shall be cut from sound trees and sawed standard size; close-grained and solid; free from defects such as injurious ring shakes and crooked grain; unsound knots; knots in groups; decay; large pitch pockets, or other defects that will materially impair its strength.

Standard Size of Sawed Timbers.—Rough timbers when sawed to standard size, shall mean that they shall not be over ¼ in. scant from actual size specified. For instance, a 12-in. x 12-in. shall measure not less than 11¾ in. x 11¾ in.

Standard Dressing of Sawed Timbers.—Standard dressing means that not more than ¼ in. shall be allowed for dressing each surface. For instance, a 12-in. x 12-in. shall, after dressing four sides, not measure less than 11½ in. x 11½ in.

Stringers.—No. 1. Longleaf Yellow Pine and Douglas Fir.—Shall show not less than 80 per cent. of heart on each of the four sides, measured across the sides anywhere in the length of the piece; loose knots, or knots greater than 1½ in. in diameter, will not be permitted at points within 4 in. of the edges of the piece.

No. 2. Longleaf Yellow Pine, Shortleaf Pine, Douglas Fir and Western Hemlock.—Shall be square-edged, except it may have 1 in. wane on one corner. Knots must not exceed in their largest diameter ¼ the width of the face of the stick in which they occur. Ring shakes extending not over ⅛ of the length of the piece are admissible.

Caps and Sills.—No. 1. Longleaf Yellow Pine and Douglas Fir.—Shall show 85 per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece; to be free from knots over 2½ in. in diameter; knots must not be in groups.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir and Western Hemlock.—Shall be square-edged, except it may have 1 in. wane on one corner, or ½ in. wane on two corners. Knots must not exceed in their largest diameter ¼ the width of the face of the stick in which they occur. Ring shakes extending not over ⅛ the length of the piece are admissible.

Posts.—No. 1. Longleaf Yellow Pine and Douglas Fir.—Shall show not less than 75 per cent. heart, measured across the face anywhere on the length of the piece; to be free from knots over 2½ in. in diameter, and not be in groups.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir and Western Hemlock.—Shall be square-edged, except it may have 1 in. wane on one corner, or ½ in. wane on two corners. Knots must not exceed, in their largest diameter, ¼ the width of the face of the stick in which they occur. Ring shakes shall not extend over ⅛ of the length of the piece.

Longitudinal Struts or Girts.—No. 1. Longleaf Yellow Pine and Douglas Fir.—Shall show one face all heart; the other face and two sides shall show not less than 85 per cent. heart, measured across the face or side anywhere in the piece; to be free from knots 1½ in. in diameter and over.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir and Western Hemlock.—Shall be square-edged and sound; to be free from knots 1½ in. in diameter and over.

Longitudinal X-Braces, Sash Braces and Sway Braces.—No. 1. Longleaf Yellow Pine and Douglass Fir.—Shall show not less than 80 per cent. heart on two faces and four square edges; to be free from knots over 1½ in. in diameter.

No. 2 Longleaf and Shortleaf Yellow Pine, Douglas Fir and Western Hemlock.—Shall be square-edged and sound; to be free from knots 2½ in. in diameter and over.

THE WESTERN RAILWAY of France is owned and operated, under certain governmental restrictions, by a company whose concession is expiring and there is an important discussion now in progress in that country concerning the advisability of consolidating the property with the 1,811 miles of State railways.

Irrigation in India.

By C. O. Burge, M. Inst. C. E.

Perhaps the most instructive irrigation work of the world and that to which, in many ways, we should look for guidance in dealing with arid districts in the West, is that to be found in India, where dams exist and are still in operation which are more than 1,100 years old, while all over the country, the British Government is at present spending millions on new works giving a handsome return on the capital outlay. In connection with irrigation, India may be divided into three distinct areas, that of the Punjab and Scinde in the northwest, draining into the Arabian Sea; the great Ganges valley, finding its outlet through the Hooghly into the Bay of Bengal; and the great peninsula tableland draining through several great rivers into the same bay.

The operations in the first named area are now in hand and being in several respects similar to pioneer work in new lands may rightfully occupy the most of our attention. India generally is full of inhabitants, and in some provinces in the Ganges valley they amount to as many as 400 or 500 per square mile, even in essentially rural districts, but the vast areas of the Punjab and Scinde to which the provision of water is now being applied, were, until a few years ago, practically uninhabited owing to the lack of moisture in the seasons when most required for the growth of food for man and beast. Eight thousand eight hundred square miles of this country are commanded, and now largely served, by the conservation of the waters issuing from the Himalayan gorges and spreading into the great rivers which are tributaries to the Indus. This immense district was practically unproductive until quite late in the last century. Since irrigation, the exports of wheat alone rose in 1898-99 to the value of $10,800,000, and in 1904-05 to $38,400,000, and as a native of India with his few wants and simple life can subsist on the produce of a very few acres, this means a large outlet for surplus population in congested districts elsewhere.

Before the British occupation, the former Mohammedan rulers had carried out some irrigation works in the northern and inhabited part of the Punjab, but they mostly consisted of canalization of drainage, for which canals on the watersheds now have been substituted. These are usually 15 ft. deep and are designed so as to have a grade giving a velocity of about 3 ft. per second, which is sufficient to prevent silt deposit, while avoiding erosion.

The first British work in the Punjab to water the settled district between the Chenab and the Sutlej rivers was undertaken in 1850, curious to say as a relief work, following the then recent conquest of the country. By this event, the Sikh warriors then fighting against the British, but subsequently, during the terrible times of the Mutiny and ever since, their most loyal soldiers, were deprived of their occupation, and to find them employment these great works were started. The water is diverted from the Ravee, a tributary of the Chenab, and the discharge there is 1,200 cu. ft. per second.

There are 370 miles of canals and 1,200 miles of distributaries. The Sirhind Canal takes off from the Sutlej near Roopoor. The minimum discharge is 2,300 cu. ft. per second, and the area dealt with is 930,000 acres in British India and 440,000 acres in Native States. In connection with the more northern works of this district, the proposed Swat River extension works which, estimated at $5,692,800 and intended to irrigate 433,000 acres in the Peshawur district, may be mentioned. The Malakand Mountain range intervenes between the new Swat River dam and the lands to be watered, and a tunnel of about a mile in length is necessary to connect them.

The dam will be at Chakdarah, the scene of fierce fighting in the tribal outbreak of 1897, and the canal before reaching the main tunnel will cross many spurs and ravines by smaller ones and viaducts. The main tunnel has a fall of one per cent. and the exit into the Indus valley at the other side will be into a rocky gorge, the water forming a cataract of 300 ft. drop in a length of 3,300 ft. The work, which will take seven years to complete, is likely to receive attention as giving facilities for the generation of electricity in connection with this outlet fall. But the work to which we have more particularly referred as serving what has hitherto been a desert, are those of the Chenab, the Jhelum and the Jamros districts.

The Chenab weir is 4,000 ft. long divided by piers 10 ft. wide into eight lengths of 500 ft. each, and hinged steel shutters are fixed into them which can be dropped down as the river rises. The canal, taken off above this weir, is 250 ft. wide at the bottom and 11 ft. deep, the maximum discharge being 10,800 cu. ft. per second. The main branches along the ridges are 400 miles in aggregate length and the distributaries about 1,200 miles, the latter carrying 500 cu. ft. per second. About 2,645,000 acres are commanded, most of which are now watered. The main subdivisions are small, about 1,100 ft. square, which are still further cut up, and over a million people from the more densely populated districts are now on the land.

The way in which the country has been divided, the sanitary precautions taken, villages and towns established, model farms, agricultural colleges, measures taken to meet the customs and prejudices of the natives, etc., were fully described in a valuable paper read at the Society of Arts, London, on May 30, by one of the Colony officers, as they are termed, who are engaged in this work. The paper was on the administrative rather than on the engineering side of the subject. Several high Indian officials took part in the discussion, and one of them gave an amusing illustration of the difficulties met with. When a junior he had to design a new village, but when the plan was brought to the site to be carried out, a native declared that it might be laid out and built if he liked, but so planned, no one would live in it. On being pressed for a reason he said most of the frontages with their doors and windows faced the East, and as it was well known in that district the demons came from that direction, they would so enter and destroy all peace and happiness. So the plan had to be altered.

The Chenab scheme will cost, when complete, about $9,600,000, and is at present returning 18 per cent. on the capital expended.

The Jhelum canal commands 1,500 acres in the district between the Jhelum and the Chenab. It carries 4,000 cu. ft. per second and is a wonderful instance of rapid work, considering the climate. The surveyors were distributed on the ground in January, 1899, headworks were begun in October of the same year and finished in May, 1901, when water was diverted, and in 1903, 280,000 acres were served. There are now over 800,000 acres irrigated, more than half the area commanded. The cost has been $5,820,770, but the return so far has been only one per cent. owing to a severe outbreak of plague, which carried off such a number of people and temporarily incapacitated so many more that a large quantity of the crops rotted on the ground and large remissions of the water rate had to be made.

The works on the third district being of a similar character need not be further referred to than to say that 6,000 miles of canal work have been completed, and the scheme gives a return of 7 per cent.

In these Punjab and Scinde schemes the duty of water is taken to be 100 acres of crop per cubic foot per second (on the average supply entering the canal at the head) in the rainy season, and 200 acres in the dry months. This means that one cubic foot per second will mature 100 acres and 200 acres according to season, or 300 acres in the year, but this varies greatly according to crop, extent of natural rainfall, and other conditions.

The loss of water on the way to its final destination varies from 50 to 70 per cent., and is never less than 50 per cent.

Two drawbacks to this roseate picture exist. Malaria seems to follow the application of water to virgin lands newly broken up, but this trouble, which has been severely felt, is no doubt but temporary. Much of the land dealt with contains alkalies, and the question whether irrigation draws these salts to the surface is now a subject for investigation by Dr. Mann, a distinguished expert in soil chemistry.

Before leaving the northwest, it may be mentioned that a proposal has been made to erect barrages across the Indus, more especially at Sukkur, similar to those of the Nile, which would add 6,000,000 acres to the cultivable area.

This part of India includes the scene of the disaffection among the natives which is now the subject of comment in the British parliament and press, and it has been alleged that it has been caused by excessive water rates being enforced, but in the discussion at the Society of Arts already referred to, officials intimately acquainted with the facts and the locality, proved that this could not be the grievance, inasmuch as there were unmistakable signs of prosperity, and there was not a single rupee in arrear, while there was, and is still, a keen competition for the land with all its dues. A proposed Colonization Bill, since withdrawn, was said to be the more likely cause, extra provisions for sanitation and other regulations in it being somewhat in advance of the ideas of the people.

As regards the second division of the subject dealing with the great Ganges valley, it is found that practically no irrigation is required for lands to the north of the river, for which the ordinary rainfall and the melting of the Himalayan snows generally suffice. The south side is not originally arid like the Punjab, but requires watering to a considerable extent at certain seasons. The Ganges Canal was completed so far back as 1848, and considering the limited knowledge of irrigation by the engineers of the time, it is a great work. The head works are at Hurdwar at the northwest extremity of the northwest province. There are 470 miles of main canal and 2,800 miles of distributaries, the former 140x10 ft., leading out from above temporary dams which are allowed to be washed away every rainy season and restored again in September. They are formed of wooden cribwork tied together and weighted with stones. This is an unusual feature in Indian Government irrigation work which is generally distinguished by its substantial character. The canal diminishes gradually as the distributaries are thrown off. At the 180th mile there is a branch 170 miles long discharging into the Ganges again near Cawnpore, and another of about equal length into the Jumna at Haripur. About 1,250,000 acres are served, the surplus augmenting the supply of the lower Ganges and other smaller canals.

There are several large works, including two aqueducts which carry rivers of considerable size over the canal, and one grade crossing dealing with the Rotmoo river. Both river and canal have sluices on the lower side. Under ordinary conditions the river sluices are closed and the river water passes through a syhpon under the canal, but in flood the canal sluices are closed and the river ones are opened, both waters temporarily escaping by the river channel. The aqueduct carrying the canal over the Solani River is 932 ft. long of fifteen 50-ft. arches, with approach fills making up nearly three miles, the waterway being 170 ft. wide and 12 ft. deep.

The lower Ganges Canal taps the river at Narora about 160 miles below Hurdwar and dates from 1878. It has 676 miles of main channel and 2,905 of distributaries watering about 1,000,000 acres. There are many other smaller systems in the Ganges valley, and an important one on the Mahunuddy River near the celebrated Juggernaut, which hardly comes under any of our three divisions. In this there is a great dam at Cuttack, from above which numerous channels water the Delta below.

We now come to the southern or tableland division, of which the main watershed is the high range running for over 1,000 miles quite close to the western coast on the Arabian Sea. Quite different conditions prevail here from those with which we have already dealt.

The chief great rivers with their large tributaries originating in this western range and crossing Southern India to the east coast are the Cauvery, Kistna, Godavery, and Pennair, 350 to 700 miles long. These pass through undulating country unsuitable for tapping by canals as in the northern rivers, until they reach the flats below the tableland near the east coast. Here the construction of the great dam across the Cauvery dates from the second century A. D., and anciently irrigated the delta, about 670,000 acres. The British restored it in 1836, and increased its operations to 1,000,000 acres at a cost of $1,200,000, the revenue now being as much as $316,800 annually.

The Kistna delta of 2,120 square miles is watered by works undertaken in consequence of the great famine of 1832. The dam is 3,714 ft. long and 20 ft. high and the flood discharge is 770,000 cu. ft. per second. There are 370 miles of canal irrigating 550,000 acres. The work cost $6,480,000 and pays well. The Godavery at the site of its dam is 2½ miles wide, but advantage is taken of three islands between which and the shores the massive dam costing $408,000 is built. The length of the main and distributing canals are 500 and 1,700 miles respectively. There are 830,000 acres watered, the total cost being $6,110,400, the return being 12 per cent.

These schemes, large as they are, only touch the fringe of Southern India, the main area being served, as regards irrigation, by earthen dams across depressions, 50 of which, aggregating 30 miles, existed before the British rule, but several of these were out of repair, and a great many have been constructed since. These reservoirs are called tanks in India. The Cumbam dam across a gorge is 300 ft. long and 90 ft. high, holding back a spread of water of eight square miles. The Chumbrambankam dam is 3 miles long and 23 ft. high, conserving 116,000,000 cu. yd. of water. Most of the dams in Southern India are simply constructed of earth without any watertight core of puddle or other material generally found essential elsewhere to prevent leakage and ultimate destruction of the work. The reason of this is that the fills were built up by natives carrying small baskets of earth on their heads, so that the constant trampling upon the embankment as it arose, closely packed every particle together, thus rendering the material water-tight. This, of course, would be impossible except in a country of cheap labor.

A somewhat peculiar irrigation scheme belongs to Southern India called the Periyar diversion. The rainfall on the sea coast side of the Western range, to which we have referred as the watershed of the peninsular supply, is much greater than on the inland side. Advantage, therefore, is taken at a place called Periyar to collect water on the western slope by a large concrete dam where the annual rainfall is 120 in., and to lead it through the mountain by a tunnel 5,704 ft. long on a grade of 1.33 per cent., to a river on the east side. This carries the water for 86 miles, where, at a suitable site, a weir is built, and 200,000 acres in the Madura district served. The cost was $2,880,000, and it pays about 3 per cent.

It may interest readers to know the approximate rates at which the class of work which is mostly largely employed in irrigation projects in India are carried out, labor saving appliances being little used, for the sufficient reason that labor at less than one-tenth American rates, is not worth saving. Ordinary excavation costs about 4 cents per cubic yard, and in rock from 40 cents up, rubble masonry $2.50 and $3, and lime concrete $1.60.

All over India irrigation on a small scale is largely carried on by the native agriculturists themselves from wells and rivers, the water being raised by the most primitive means, the most common being that of the piccotah, a bucket hung to the end of a bamboo framework lashed in the middle to a pole, the end of the framework being alternately lifted and depressed by a coolie running rapidly backwards and forwards upon it.

In the middle of last century there were about 4,000,000 acres irrigated by the Government, in 1875 there were 20,000,000, and there are now over 44,000,000, costing over $144,000,000, on which there is an average return of about 7 per cent., by which the general taxation of the Indian Empire is relieved. Of the 44,000,000 acres 17,000,000 are served by canals, 8,000,000 by tanks, and 19,000,000 from wells and other sources. Yet with all this progress much remains to be done. Mr. R. B. Buckley, C.S.I., M. Inst. C.E., to whose able work on "Irrigation in India" we are indebted for the above figures, states that it is estimated that 59 per cent. of the total rainfall is absorbed in vegetation, 35 per cent. reaches the seas by rivers, the remaining 6 per cent. only being saved for irrigation, and he points out many definite schemes by which this latter percentage could be increased.

Immense sums have been expended, and sometimes wasted in famine relief. In 1860-61, half a million persons were relieved in the northwest provinces at a cost of $3,600,000. In 1873-74 $31,200,000 were expended in averting an expected famine in Behar, and these are only instances. This represents a state of things which, owing to the extension of irrigation, is now hardly possible, while the construction of railways, originally by private enterprise and later by Government, has enabled grain from fertile districts to reach quickly and cheaply those afflicted with droughts.

The inhabitants of India thus benefited vary among themselves in different provinces in race, customs, characters and religion as much as do the widely different nations of Europe, and the progress described would have been impossible in an independent India, with its contentions and jealousies absorbing its energy, contentions which disappear under the enlightened and forceful Anglo-Saxon rule.

RATS caused the failure of a block stone pavement on a Paterson, N. J., street four times during the last year. On each occasion the street surface sank about 2 ft., and repairs were made by excavating several feet below the foundation and filling the space with earth. On the occasion of the last trouble a diligent search was made, which showed that the earth had been taken out from below the pavement by rats, which carried it into a sewer through an opening left for a house connection. This opening had been closed by a board, which the rats had eaten through. They evidently dropped the earth burrowed out to form their nest through this hole into the sewer, where it was washed away.

Standard Specifications for Steel Rails.

Recommended by the Committee on Standard Specifications for Iron and Steel of the American Society for Testing Materials.

Process of Manufacture.—(1) (a) The entire process of manufacture and testing shall be in accordance with the best current practice, and special care shall be taken to conform to the following instructions:

(b) Ingots shall be kept in a vertical position in the pit heating furnaces until ready to be rolled or until the metal in the interior has time to solidify.

(c) No bled ingots shall be used.

(d) There shall be sheared from the end of the blooms formed from the top of the ingots not less than x per cent., and if, from any cause, the steel does not then appear to be solid, the shearing shall continue until it does.

(The percentage of minimum discard in any case to be subject to agreement and it should be recognized that the higher this percentage the greater will be the cost.)

Chemical Composition.—(2) Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	50 to 59 Pounds, Per cent.	60 to 69 Pounds, Per cent.	70 to 79 Pounds, Per cent.	80 to 89 Pounds, Per cent.	90 to 100 Pounds, Per cent.
Carbon	0.35-0.45	0.38-0.48	0.40-0.50	0.43-0.53	0.45-0.55
Phosphorus, shall not exceed	0.10	0.10	0.10	0.10	0.10
Silicon, shall not exceed	0.20	0.20	0.20	0.20	0.20
Manganese	0.70-1.00	0.70-1.00	0.75-1.05	0.80-1.10	0.80-1.10

Drop Test.—(3) One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected from every fifth blow of steel. The test shall be taken from the top of the ingot. The rail shall be placed head upwards on the supports, and the various sections shall be subjected to the following impact tests under a free falling weight:

	Weight of Rail, Pounds Per Yard.			Height of Drop, Feet.
	45	to and including	55	15
More than........	55	"	65	16
More than........	65	"	75	17
More than........	75	"	85	18
More than........	85	"	100	19

If any rail break when subject to the drop test, two additional tests, taken from the top of the ingot, will be made of other rails from the same blow of steel, and if either of these latter tests fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

Finishing Temperature.—(4) The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot-saws, for a 30-ft. rail of 100 lb. section, of 6 11/16 in., and 1/16 in. less for each 5 lb. decrease of section. These allowances to be decreased at the rate of .01 in. for each second of time elapsed between the rail leaving the finishing rolls and being sawn. No artificial means of cooling the rails shall be used between the finishing pass and the hot-saws.

Drop Testing Machine.—(5) The drop testing machine shall have a tup of 2,000 lb. weight, the striking face of which shall have a radius of not more than 5 in., and the test rail shall be placed head upwards on solid supports 3 ft. apart. The anvil block shall weigh at least 20,000 lb., and the supports shall be part of, or firmly secured to, the anvil. The report of the drop test shall state the atmospheric temperature at the time the test was made.

Chemical Analyses.—(6) The manufacturer shall furnish the inspector, daily, with carbon determinations for each blow, and a complete chemical analysis every twenty-four hours, representing the average of the other elements contained in the steel, for each day and night turn. These analyses shall be made on drillings taken from a small test ingot.

Weight Section.—(7) Unless otherwise specified, the section of rail shall be the American Standard, recommended by the American Society of Civil Engineers, and shall conform, as accurately as possible, to the templet furnished by the railroad company, consistent with paragraph No. 8, relative to specified weight. A variation in height of 1/64 in. less, or 1/32 in. greater than the specified height, and 1/16 in. in width will be permitted.

(8) The weight of the rails will be maintained as nearly as possible, after complying with paragraph No. 7, to that specified in contract. A variation of one-half of one per cent. for an entire order will be allowed. Rails shall be accepted and paid for according to actual weights.

Length.—(9) The standard length of rails shall be 30 ft. Ten per cent. of the entire order will be accepted in shorter lengths, varying by even feet to 24 ft., and all No. 1 rails less than 30 ft. shall be painted green on the end. A variation of one-fourth of an inch in length from that specified will be allowed.

(10) Circular holes for splice bars shall be drilled in accordance with the specifications of the purchaser. The holes shall accurately conform to the drawing and dimensions furnished in every respect, and must be free from burrs.

Finish.—(11) Straightening.—Care must be taken in hot-straightening the rails, and it must result in their being left in such a condition that they shall not vary throughout their entire length more than 5 in. from a straight line in any direction, when delivered to the cold-straightening presses. Those which vary beyond that amount, or have short kinks, shall be classed as second-quality rails and be so stamped.

The distance between supports of rails in the gagging press shall be not less than 42 in.

Rails shall be straight in line and surface when finished—the straightening being done while cold—smooth on head, sawed square at ends, variation to be not more than 1/32 in., and, prior to shipment shall have the burr occasioned by the saw cutting removed, and the ends made clean. No. 1 rails shall be free from injurious defects and flaws of all kinds.

Branding.—(12) The name of the maker, the weight of rail and the month and year of manufacture shall be rolled in raised letters on the side of the web, and the number of blow shall be plainly stamped on each rail where it will not subsequently be covered by the splice bars.

Inspection.—(13) The inspector representing the purchaser shall have the free entry to the works of the manufacturer at all times when the contract is being filled, and shall have all reasonable facilities afforded him by the manufacturer to satisfy him that the finished material is furnished in accordance with the terms of these specifications. All tests and inspections shall be made at the place of manufacture prior to shipment.

No. 2 Rails.—(14) No. 2 rails will be accepted up to ten (10) per cent. of the whole order. Rails that possess any injurious defects, or which for any other cause are not suitable for first quality, or No. 1 rails, shall be considered as No. 2 rails; provided, however, that rails which contain any physical defects which impair their strength shall be rejected. The ends of all No. 2 rails shall be painted white in order to distinguish them.

Book Notes.

The great variety of products made in presses is one of the most interesting features of special machine work at the present time, and is an explanation of the very low price at which many kinds of jewelry, watches, and machine parts can be sold at a fair profit. A general description of the tools employed in such manufacture and of the numerous different classes of operations conducted on presses is given in a book on "Punches, Dies and Tools for Manufacturing in Presses," by Mr. Joseph V. Woodworth, author of a book one die-making which has had a wide circulation. The author's object in preparing the book named has been to prepare a cyclopedia of die-making, punch-making, die-sinking, sheet-metal working, special tools and mechanical devices for piercing, punching, cutting, bending, forming, drawing, compressing, embossing, forging and assembling metal parts by the press. It does not go into the details of die making to the extent of the author's previous book, but aims to give a comprehensive review of the field of operations carried on by presses. A large part of the information has been drawn from the author's personal experience, but he has wisely supplemented this by information from shop journals, so that the book covers its field in a satisfactory manner. (New York, Norman W. Henley Publishing Co., $4.)

A book which is full of good suggestions for draftsmen is Mr. Frank T. Daniels' "Text-book of Topographical Drawing." It is written for students who have acquired some facility in the use of ordinary drafting instruments and does not take up the subjects customarily given in a good course in mechanical drawing. The book opens with an explanation of the instruments used in the special work of the topographical draftsmen, and then explains various preliminary problems and operations with which he must be familiar. The method of plotting survey notes is explained and then detailed directions are given for topographical drawing in ink, which are followed by similar directions for color work. The advice regarding such work is particularly good, in that it does not attempt to teach the delicate methods employed on the highest-grade maps but covers the usual range of topographical work in a comprehensive manner, showing the succession of steps to be taken in laying out the map as a whole and in making each of the conventional signs. The notes concerning color work are particularly good, although the student should understand that it is impracticable to produce with water colors the peculiar effect show in the lithographed color plates which are given as models in the book. A chapter on surface forms and earthwork contains a considerable section on the computation of earth volumes which does not come within the scope of topographical drafting, although it is of some interest as showing the value of certain kinds of topographic work. There are good chapters on the conventional treatment for surfaces and sections, with samples of such conventions, and on methods of copying, enlarging and reducing drawings. (Boston, D. C. Heath & Co., $1.50.)

A FIRE IN A CONCRETE BUILDING in Brooklyn recently demonstrated that while such a conflagration may not have serious effect on the structure it is desirable that the floor systems, particularly the landings in stairways, should be so designed that the water which collects on them when a fire is extinguished may be readily drained away. In the case of the Brooklyn fire the only way for the flood of water poured on the contents of the building to escape was down the stairs, which caused a great deal of inconvenience and unnecessary damage to the stock in the building.